AN ASSESSMENT OF THE PUBLIC'S WATER RESOURCE KNOWLEDGE AND IMPLICATIONS FOR WATER EDUCATION

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CHAPTER I

NATURE OF THE PROBLEM

Introduction

The purpose of this chapter is to express the importance and dynamics of water resources. The problem to be studied and the significance of the study will be discussed. Definitions of terms associated with water resources, as well as those specific to this study, will be provided for better understanding of the study.

> Behold, I will do a new thing; now it shall spring forth; shall ye know it? I will even make a way in the wilderness, and rivers in the desert. The beasts of the field shall honor me, the dragons and owls: because I give waters in the wilderness and rivers in the desert, to give drink to my people, my chosen.
>
> -Isaiah, 43:19-20

Water is so essential to life it is difficult to exaggerate its importance. Water, a compound almost as rare in the universe as life, is perhaps synonymous with life. All plant and animal life, including *Homo sapiens*, are dependent on this natural resource that was, until recently, relatively pure, plentiful, and inexpensive in much of the United States.

Water possesses many unique physical and chemical properties. It is the unique nature of water, which results in the dynamic water system of the earth. Driven by the sun, it is the earth's hydrologic system that makes the planet habitable. For example, ocean currents and atmospheric circulation of water modifies our climate by storing and redistributing heat around the earth.

The unique properties that contribute to the dynamic nature of the world's water system also aid in waters' ability to be easily polluted. Water is referred to as the universal solvent, for it dissolves more substances than any other compound. The ability of water to dissolve many substances results in natural and man-made water quality problems. Water dissolves and distributes material such as domestic sewage, sulfates, nitrates, phosphorus, petroleum wastes, pesticides, heavy metals, and other potentially undesirable substances.

Water contamination is a world wide problem. In European countries such as Norway and Sweden several thousand lakes have been acidified, and entire fish populations have been lost as a result of sulfur and nitrogen based acidic inputs. Indications are that similar process is underway in portions of the northeastern U.S. and Canada (Barnes, 1979; Overrein, 1981).

Worldwide, millions of metric tons of petroleum hydrocarbons enter the aquatic environment annually and are a major source of marine pollution (Travers and Luney, 1976). In aquatic settings bivalves and other aquatic organisms concentrate noxious and toxic substances from their water environment due to waters that are polluted by domestic sewage, petroleum, petroleum byproducts, and industrial wastes (Mix et al., 1977). Other problems occur with synthetic organic chemicals, agricultural chemicals, heavy metals, and petroleum when they enter the aquatic environment as pollutants generated by human activity. Certain pollutants are actual or potential carcinogens, which may upon contact with aquatic organisms accumulate, metabolize and translocate the pollutants or its metabolites (Kraybill, 1975).

Pollution is not the only world wide problem associated with water. Along with the pollution of our water supply, our demand on the available supply has grown exponentially. Our per capita use during the past fifty years has increased 350 percent. It is projected that by the year 2000 net use will be slightly below the lower limit of available usable water and near the estimated upper limit of supply by 2020 (Mills, 1977). Water rationing can be found at different points throughout the United States in any given year. Droughts, whether in India or in Africa, evolve into international problems leading to programs to relieve the sufferings of millions affected by such events. This is evident with the current situation in Ethiopia where hundreds upon hundreds die daily due to drought.

Conflicting demands for limited water supplies will undoubtedly escalate in coming years. For example, water taken from the Colorado River to irrigate orange groves in California is not available for use in the homes of Los Angeles. And water used in Wyoming to operate a proposed coal slurry pipeline would not be available for agriculture. Building major dam projects to increase water supplies or control floods usually meets with farmer opposition since reservoirs tend to flood the better farm lands. The idea of requiring industries to meet higher quality standards raises fears of causing the U.S. to become less competitive in the world market. Conflicts such as these are sure to result in more governmental intervention instead of less. Conflicts about water supplies and water quality standards are already evident between various levels of state government, between states, and between countries.

Should mankind be able to cure the immediate problems of potable supply and demand it still must be realized that water is a finite resource. Legislation has been passed, laws have been decreed, and regulations are enforced, but the water remains the same. We are using the water that was used by the colonists. The water we (mankind) have at our disposal now is all that we have or ever will have. Less than 3/10 of one percent of the world's water is potable. It is this water that is utilized extensively by industries, municipalities, irrigation, etc., and therefore is becoming increasingly more polluted (Wetzel, 1982).

The majority of America's school children (and their parents) know little about the importance of water in producing our food, clothing, shelter, other necessities, and the luxuries of life (Jarman,1983). Many people know little more about water other than it comes from the tap. People are for the most part unaware of the source of their water supply or of the myriad of problems associated with providing their families and cities with pure and adequate amounts of water (Jarman, 1983). People are typically quite ignorant about the amount of water needed to produce the food so readily available in supermarkets, or to produce the cotton for their clothes (Barnett, 1984). Rural people as well as city people are unaware of the vast amounts of water used in industries such as steel, chemical, paper manufacturing, and electrical power generation (Barnett, 1984).

It is a common belief that knowledge about water resources are important topics for study in our schools (Amend, 1983; Bates, 1982; Miller, 1979; Mills, 1977; Smith, 1984). The understanding of the chemical and physical properties of water is an important topic. Pollution abatement, conservation, the interrelations of water with aspects of the environment and the decision making skills involved in water related environmental concerns are all important concepts to a voting public and/or those who would assume leadership roles (Bates, 1982; Mills, 1983).

Statement of the Problem

The purpose of this study is to collect data concerning the knowledge of Oklahoma's water resources possessed by a sample of the general public attending the Tulsa State Fair.

To make informed decisions concerning water issues it is necessary for a citizen to have knowledge on which to base their decisions. Water knowledge assessments of special groups have been conducted previously (Bates, 1982; Mills, 1983; Smith, 1984). However, the conclusions of these previous studies to the general public was inferred, not studied directly. No studies on Oklahoma's general populace were found in the review of literature.

An assessment of water knowledge possessed by a sample of the general public would be helpful to confirm the validity of previous research conducted on highly selected study populations.

In addition a comparison of rural and urban individuals as well as age groups in the general population would be useful in further clarifying education levels.

This study deals with the stated problem by answering the following research questions:

1. What is the level of public water resource knowledge within the general public?

2. Do urban as opposed to rural citizens possess

greater knowledge of water resources?

3. Do all the participants 30 years of age and under possess greater knowledge of water resources than all the participants over 30 years of age?

4. Do urban citizens over 30 years of age opposed to rural citizens over 30 years of age possess greater knowledge of water resources?

5. Do urban/30 years of age and under know more than their rural counterparts?

6. Do rural/30 years of age and under know more than the urban/over 30 years of age participants?

7. Do urban/30 years of age and under know more than the urban/over 30 years of age participants?

8. Do the results from this research support findings from earlier, similar research?

9. What concepts are best understood?

10. What concepts are least understood?

Significance of the Study

Water is a renewable resource. However, due to geographic location, weather conditions, population distribution, pollution, and many other factors, water management and distribution are very complex issues. Today water is demanded in ever increasing amounts to supply and satisfy the many and varied needs of a modern society. Citizens should be aware of the consequences involved in water management decisions, and be educated to make <u>wise</u> <u>choices</u> in the use and protection of water resources.

We are becoming increasingly aware of the fact that our continuing national well being is subject to varied social, economic, and natural resource constraints. The world we live in is dynamic, and many of our once abundant resources are now inadequate. Humans are innovative creatures and have often trusted their technological ingenuity to push back constraints and resolve difficult predicaments. However, it is important to realize that technological innovation also creates new restraints.

Decisions concerning trade offs are often difficult to make. Informed citizens should consider social, economic, and institutional factors which relate to water and its use. It is also important to understand the physical qualities and properties of water. Only when we understand the ramifications of water resources constraints and attitudes can we address the issues involved and better predict the consequences of the choices. With adequate knowledge we will be able to wisely and successfully manage our precious water resources.

This research, within the limits of the study, will determine at what level Oklahomans are informed on their state's water resources. More importantly it is anticipated that the information gained from the survey will be helpful to those responsible for school and adult education programs that focus on Oklahoma's water resources.

Assumptions of the Study

To complete this study, the following assumptions will be made:

1. The participants responded to the questionnaire honestly.

2. The Water Resources Survey Instrument designed by the author is a valid way of identifying the knowledge of the participants.

Limitations of the Study

The subjects of the study are limited to those of the public who voluntarily answered the survey instrument at the 1984 Tulsa State Fair. The survey population is hoped to be a random sampling of the people of Oklahoma.

The Tulsa State Fair was selected since it was the authors opinion that it offered an equal mix of rural and urban people. This opinion was supported by information gained from the Tulsa State Fair Board (1985). The length of the survey instrument was limited in size and scope in an effort to maximize the number of participants.

Definitions of Terms

The following definitions are of water related terms that are unique to this study, listed alphabetically. Also included are terms to help the reader define technical water terminology.

Acre-foot - the amount of water required to cover an acre of land on foot deep; about 324,851 U.S. gallons.

Age - in this study it consists of two age groupings with one group consisting of participants age 17-30 and the second comprised by participants age 31 and up.

Aquifer - a geologic formation, group of formations, or part of a formation that is water yielding.

Buffering capacity - the ability of a solution or system, such as lake water or soil moisture, to resist changes. An example is bicarbonate in water that is capable of neutralizing both added acids and bases and thereby maintains the original acidity or basicity of the solution.

Carrying capacity - the upper limit of a system to support all components within the resources available.

Consumptive use - that part of water withdrawn which is no longer available for use because it has either evaporated, transpired, been incorporated into products, or otherwise removed from the water environment.

Contamination - any degradation of natural water quality caused by man's activities.

Degradation - in water, any process that reduces the quality of a water source.

Effluent - a waste liquid that discharges into the environment.

Eutrophication - an enriched condition of aquatic ecosystems characterized by increased production of certain plants and animals, reduced types of plants and animals, and a reduction in the ability of many organisms to resist changes in the environment.

Evapotranspiration - loss of water from the soil both by evaporation and by transpiration from the plants growing upon it.

Groundwater - water beneath the land surface stored in a saturated zone in geologic strata.

Hazardous waste - any waste discharged into the environment which possesses a present or potential danger to humans, other animals, or plants.

Heavy metals - metallic elements required for plant and animal nutrition but which become toxic at higher levels; examples are copper, mercury, cadmium, and lead.

Hydrological cycle - the cyclic processes of water movements from the atmosphere, its inflow and temporary storage on and in land, and its outflow to the oceans. The cycle consists of three principal phases: precipitation, evaporation, and surface and groundwater runoff.

Nonpoint source - a contaminant source which emits wastes in a diffuse or intermittent manner.

Point source - a confined or defined source of water contamination.

Pollutant - any substance which becomes dissolved in water and impairs its usefulness.

Potable - water of a suitable quality for drinking without harmful effects.

Recharge - the addition of water to a ground or surface water system by natural or artificial processes.

Retention time - the period of time that water remains in a given reservoir (lake, stream, as vapor in the atmosphere, etc.).

Riparian Rights - the right to water by owning land that is adjacent.

Runoff - direct or overland flow of rainfall not absorbed by soil, evaporated, or transpired by plants, thus finding its way into streams or surface flow.

Rural - participants who classified themselves as rural.

Surface water - water stored on the land surface, including lakes, rivers, streams, and oceans.

Toxicity - the ability of a material to produce injury or disease in a living organism upon exposure.

Transpiration - the process by which water passes as water vapor from organisms, especially plants, through membranes or pores to the atmosphere.

Urban - participants who classified themselves as urban.

Water quality - the chemical, physical, and biological properties of water and their suitability for a particular purpose.

Water Resource Knowledge- the knowledge necessary to properly respond to the questions in the water resource knowledge test.

Water Resource Knowledge Test- the 50 questions used within the scope of this study to test the participants water resource knowledge.

Watershed - the drainage area or region bounded by water flow to a particular stream system or body of water.

Water table - the surface of an unconfined groundwater body, defining the top of the saturated zone.

Xenobiotic - a chemical compound (such as a drug, pesticide, or carcinogen) that is foreign to a living organism.

The purpose of this chapter has been to give a brief overview of the importance and dynamics of water resources, to state the problem and significance of the study and to present definitions that will allow better understanding of the study.

CHAPTER II

SELECTED REVIEW OF LITERATURE

Procedure for Literature Review

The development of the review of literature involved a thorough ERIC (Educational Resources Information Center) and library search. ERIC, a computerized clearinghouse at Ohio State University administered by the National Institute of Education, allow access to publications on a wide array of topics. Descriptors used in the ERIC search were marine education, test manuals, toxicology, waste water, water, water quality, environmental education, adult education, drinking water, post secondary education, water pollution, test construction, water resources conservation, and environmental standards. Literature was reviewed from the year 1955 to present. A review of thesis and dissertation abstracts was also made from the year 1960 to present. The following is a synthesis of the literature relevant to this study.

History

Community sites of people have been found in caves near

Kenton, Oklahoma yielding evidence of people more then 4,000 years old. Archeologists have also found evidence that man was living in Oklahoma 15,000 to 20,000 years ago (McReynolds et al., 1975).

It is known that the Spiro Mounds people in eastern Oklahoma's Arkansas River Valley comprised the center for trading in this part of the United States. The Spiro Mounds people were a force from about 500 to 1300 AD. They obtained this position of power due to their control of the waterways (Stovall, 1982). Many believe that the western plains people overpowered them, but evidence tends to indicate that climate was also a critical factor. Francko (1983) indicates that there was a major climatic change in this midwestern region of the United States about 1500 AD. This was the same time that the Spiro Mound culture vanished. Evidence has been found that a powerful Indian tribe (The Mill Creek People) in Iowa that had ruled for centuries vanished at the same time in history as the Spiro Mounds culture in Oklahoma. The Mill Creek People's power base was due to agriculture (raising of corn), so when the regional climactic change occurred the culture could not adapt and so vanished. Iowa is at this time in history the center for corn production in the United States.

Many historians now believe that the regional climatic change caused drought and dried up the river beds that were so essential to the commerce of the Spiro Mounds people.

These water related factors eroded their importance as an economic force (Stovall, 1978).

In the 1500's the Spanish and French discovered the Mississippi River and it became the golden thread that would allow them to discover other river systems, particularly the Red and the Arkansas. Up these rivers into Oklahoma came conquistadors, explorers, trappers, traders, settlers and immigrants (McReynolds, 1975). In 1541 Francisco Vasquez de Coronado came into Oklahoma by following rivers to seek gold and treasure. In years to come the U.S. Government would send many of the people in the Five Civilized Tribes along the same rivers to Oklahoma.

In Oklahoma's first land run in 1889 it is recorded that water was at a premium. It sold for more than flour, lard, potatoes or whiskey. People lined up for hours upon hours in the hot Oklahoma sun in order to pay one dollar for a cup of water (McReynolds, 1975).

The importance of water could not be more vividly illustrated than the Dust Bowl days of the 1930's when, due to lack of adequate amounts of precipitation, there was a mass exodus from Oklahoma and other southwest states. In response to widespread water problems, the Oklahoma Legislature created the State Planning and Resources Board in 1935 which held in its jurisdiction parks, forests, and water resources (Oklahoma Water Resources Board, 1980). Currently in Oklahoma we face the prospect of depletion of the state's natural resources that have allowed us to prosper. With depletion of the state's natural resources plus an ever expanding population, greater demands are being placed on a limited supply. We now have a new challenge to face.

Current Water Crisis

"In nature there are neither rewards nor punishments--there are consequences."

R.G. Ingersoll

The current world wide water crisis is well documented on television, radio and in the daily papers. Daily, on live television we can see men, women, and children die due to inadequate water resources. The people of Oklahoma are not presently facing this type of crisis but we do have water problems and these problems that will become more serious as time goes by. The media attention has contributed a great deal to the awareness of the general public of water problems in America.

The amount of water within the state is enough, in a total or statewide water budget sense, to meet future requirements. The problem lies in the fact that water is not evenly distributed. Western Oklahoma is constantly being threatened by droughts and is frequently subjected to severe water shortages. These shortages are circumvented by irrigation from the Ogallala aquifer which is also in danger of depletion. Eastern Oklahoma has an abundance of surface water, ground water, and plentiful rainfall, yet in some areas of eastern Oklahoma there are water quality problems.

Present water use for all purposes in Oklahoma is about 2.4 million acre-feet annually. Projections of future water use indicate more than 6.9 million acre-feet will be needed by the year 2040 (Sunday Oklahoman, 1984). During the next two decades, 1 million more acre-feet of water will be needed for irrigation than is presently being used. There will in this same time span be a need for an additional 500,000 more acre-feet for power and 300,000 acre-feet for industrial and municipal use. All areas of the state have been subject to water shortages due to quality or quantity problems. It is evident that unless the state's water resources are managed properly Oklahoma's potential will never be realized.

Dynamics of Freshwater in Oklahoma

The hydrologic cycle is a global phenomenon powered by solar energy and gravity. Water evaporates from oceans and continents (mostly from the former) and is carried into the atmosphere. It may drift for hundreds of kilometers before returning to the earth's surface as precipitation (rain, snow, hail or sleet). After falling, precipitation may undergo any one of five different processes. First, it could be intercepted by vegetation which prevents it reaching the ground. Secondly, it could collect on the earth's surface where impermeable soils or rocks occur. As a third possibility the moisture could seep into permeable rocks or soils. Fourth, the precipitation could be a contribution to streams which flow to lower ground and ultimately reach the oceans. Fifth, if it falls over the ocean it recombines with the surface waters (Franks, 1972).

When precipitation ceases, water in pools or on vegetation reevaporates. Streams flow into river systems and the water eventually discharges into lakes or seas. Some water percolates into the earth and ultimately reaches the natural level of free groundwater, the water table. An aquilude is a water tight geological stratum, hence groundwater tends to flow horizontally and may get to land at a lower altitude and reappear at the surface as a spring or enter a lake or river. Such an underground water reservoir below a water table constitutes an unconfined aquifer. An aquifer may be confined if the water bearing stratum is trapped between two aquiludes. In such a case, the level to which the trapped water would rise is where there is no overlying confining stratum This is essentially an imaginary surface and is termed the piezometric surface. Completely confined aquifers are extremely rare because the aquilude overlying them is usually faulted and thus can permit water to leak through. Additionally, if such aquifers have any outflow, no matter how small, water losses must be replaced if they are to continue to exist. Areas where infiltration takes place are known as recharge areas. For confined aquifers the recharge area is usually located at a higher elevation where the aquifers are actually no longer confined.

The main processes involved in the hydrologic cycle are evaporation, precipitation, interception, infiltration, seepage, storage in various water bodies and two others now to be discussed, runoff and transpiration.

Where water falls on an impermeable land surface it flows away as runoff. In fact, the principal impact which man makes upon the hydrologic cycle is found in his interference with natural surface runoff.

Transpiration occurs as a result of the drawing up of soil water through capillary action by means of roots and vegetable matter to leaves which return it, as water vapor, to the atmosphere. Transpiration combines with moisture from above to return water to the atmosphere. Where evaporation and transpiration occur in conjunction, they may be termed evapotranspiration.

The functioning of the hydrologic cycle depends upon solar energy which evaporates water and warms humid air. Of the two million terra-watts continuously impinging on the earth, just over half actually reaches the surface, the rest being absorbed or reflected by clouds and the atmosphere. Of that arriving on the surface, about one third is used continually in evaporation. The atmosphere and the earth are considered as separate entities. The radiation and conduction fail to have balanced heat budgets because the planetary surface has a net gain and the free atmosphere a net loss. However, a link between gain and loss is provided by the hydrologic cycle. That portion of the heat absorbed by the earth's surface which is expended in evaporation is thereby transferred to latent heat which is later released to the atmosphere when water vapor condenses to form clouds.

Evaporation is greatest where relatively cool air sweeps over warm oceans. The highest evaporation values are found in the northern hemisphere in the Atlantic and Pacific trade wind belts south of 30 degrees north. Additionally, high evaporation values occur over the northwest Pacific and north Atlantic oceans in the winter when cold and dry continental air masses move over warmer waters.

The "life span" of water vapor molecules in the atmosphere is variable, ranging from a hour to several days. Latent heat is normally liberated far away from the regions where evaporation took place. This is especially true in the trade wind belts which supply much of the water vapor precipitated in the middle and high latitudes. The circulation of water may be seen to comprise a crucial part of heat transfer from low to high latitudes as well as from oceans to continents.

Hydrology

The modern science of hydrology was initiated in the eighteenth century (Bowen, 1982). Thereafter, continuous attempts have been made in order to refine the understanding of every distinct phase of the hydrologic cycle as well as interrelationships between the various phases. For this study we will focus on the surface water, ground water, and drainage basin characteristics in order to better understand the complexity of Oklahoma's water resources.

Surface Waters

In Oklahoma the majority of our lakes are man-made impoundments. Although rivers and streams are also considered surface waters they will be discussed later in relation to drainage basin characteristics.

Lakes constitute small to moderately large inland bodies of water, either fresh or saline, with surfaces exposed to the atmosphere and without access to the sea or having such access solely by means of rivers. They occupy depressions into the zone of saturation in the environmental soil and rock, derive their water from rain, melted snow, ice, etc., and are small scale agents of erosion in which waves may develop, controlled by the same factors governing waves in the oceans.

The classification of lakes are usually based upon the origin of the depression in which they occur. Depressions are usually caused by some catastrophic event such as glaciers or earthquake fissures, or are man made (Wetzel, 1981). In Oklahoma the two common types are natural oxbow lakes and reservoirs which are man made lakes or impoundments caused by the damming of of a stream or river channel.

Surface Water Quality

The hardness of water is caused by the dissolved mineral complexes of calcium and magnesium, usually in the form of bicarbonates or sulfates. Water with a total hardness of less than 60 to 120 mg/l does not seriously interfere with the use of water for most household purposes. In Oklahoma's surface water the hardness varies considerably. It ranges from 50 mg/l in the eastern part of the state to 400 mg/l in western Oklahoma. Other minerals affect the individual user by their presence or absence. These will be discussed later under the heading of Degradation of Oklahoma's Water Resources.

Ground Water

Ground water is that part of the hydrosphere which fills the pores and cracks in the soil and rocks within the lithosphere. It is also known as underground, subsurface, or subterranean water. In all continents, these underground reservoirs contain much more usable water than is found in all the surface streams and lakes combined. In addition to supplying water for man's use, ground water acts as an agent of gradation--i.e., dissolving, eroding, transporting and depositing mineral matter in the earth's crust. The occurrence of ground water depends on a number of factors, by far the most important of which is the porosity of the ground. Other factors include permeability, rock structure, slope, rate of precipitation, rate of evaporation, and type and quality of vegetation.

Unlike the rivers and streams, the flow of ground water through aquifers is extremely slow and shows no turbulence. The movement through interconnecting pore spaces in saturated materials is called percolation. When water sinks into the ground during percolation, it is pulled downwards by the force of gravity. After reaching the water table it begins to accumulate and seek its own level by moving horizontally.

The rock formations, or group of formations, that contain sufficient saturated material to yield significant quantities of water is called a ground water basin or aquifer. The amount of water available depends on the saturated thickness, the area of the basin and the specific yield. The amount of water that can be pumped from a well on a perennial basis without depletion of the ground water in storage depends on the amount of recharge from precipitation.

In Oklahoma the major water bearing formations are sand, gravel, limestone, dolomite, sandstone, and gypsum. Of all of Oklahoma's natural resources ground water is considered priceless. Ground water can be found throughout the state in 12 major basins and 150 basins of less significance. Ground water is responsible for suppling 61 percent of the total water reported used in the state, which includes 80 percent of the state's irrigation needs (Sunday Oklahoman, 1984).

Ground Water Quality

The chemical composition of the rocks with which the ground water comes into contact determines the chemical quality of the ground water. It is mandated by the 1974 Federal Water Pollution Control Act that water used for industrial purposes, irrigation and other beneficial uses must meet federal standards. In 1977 Oklahoma was the first state to meet the government's 1974 water quality standards. Since that time we have digressed. Degradation of Oklahoma's water resources will be discussed further under the heading of Degradation of Oklahoma's Water Resources.

Drainage Basins

In the hydrologic cycle more evaporation takes place from the oceans than the land due to the oceans' enormous surface area. Therefore precipitation is greater on the land masses rather than vice-versa. Once on the earth's surface it is the characteristics of the various drainage basins that determines how fast the water returns back to the oceans (Francko, 1983). As stated earlier it is at this stage of the hydrologic cycle which man has the ability to interfere with the cycle and does usually to the detriment of that particular region's hydrologic cycle and water quality.

Oklahoma is drained by two major river basins: (1) the Arkansas River in the north and (2) the Red River in the south. These two rivers enter the state from neighboring states, and increase in volume from tributaries as they make their way to the Mississippi River. An estimated 34 million acre-feet of water leaves the state each year by way of these two rivers (Oklahoma Water Resources Board, 1984). At this time,however, this 34 million acre-feet is not considered a great loss since the water is poor in quality and limited in its beneficial use (Oklahoma Water Resources Board, 1980).

The Arkansas River and its tributaries drain about two thirds of Oklahoma. The Arkansas River enters Oklahoma from Kansas and although the majority of its tributaries emit clean water its major tributaries, the Cimarron and Salt Fork Rivers, deliver brackish water.

The Red River and its tributaries drain the remaining one third of the state. The primary water quality problem in the Red River is silt loading. The Red River begins in New Mexico and comprises the border between Texas and Oklahoma. The only major reservoir on the Red River is

Lake Texoma.

Climatic Factors

Climates are governed by processes that are not entirely predictable. Its also a known fact that climatic changes occur over the United States in a cyclical pattern decades in duration (Francko, 1983). We have set our present water use patterns according to the supply during the past several decades. These decades are believed to have been an unusually wet time period. Over a several hundred year time span the typical climate of the United States is dryer and hotter than what we have experienced these past several decades. Evidence indicates that we are returning to the hotter, dryer weather of our historical past (Francko, 1983). Should this prove true, our water supplies will dwindle at a more accelerated rate than already feared. Should current theories prove true about climatic changes, a change would most greatly effect the Southwest and the High Plains, already water poor. Oklahoma's farming land would be the most affected. Irrigation in the High Plains portion of Oklahoma from the Ogallala aquifer is already in jeopardy and any more stress to that system could possibly be a prelude to another Dust Bowl (Francko, 1983).

As in other southern Great Plains states, Oklahoma lands have baked and cracked under extended droughts approximately every 20 years. The drought of the 1930s was the longest in Oklahoma history, lasting the entire decade. The drought of the 1950s, however, was more widespread in Oklahoma, weather experts say, and ranked among the more destructive of the past 400 years nationwide. In the 1970s, the drought was merely "mild to moderate," according to the Oklahoma Climatological Survey in Norman, though in 1980 the state experienced one of the hotter summers on record, causing more than 360 communities water shortages. About half the time, Oklahoma is undergoing drought, which the National Weather Service defines as abnormally dry weather sufficient to cause serious water related damage, such as crop loss.

Climatic cycles occur but are unpredictable and mankind has no control over them. In Oklahoma we know that climatic changes are real and have experienced their severity. Possible climatic changes must be taken into account in any future assessment of water availability.

Water Uses in Oklahoma

Irrigation

The primary use for water worldwide and in the United States, and particularly in Oklahoma, is agricultural (Van Dam, 1977; Wollman and Bonem, 1971). Irrigation demands the greatest amount of water today and demand is expected to grow (Wollman and Bonem, 1971). Wollman and Bonem also reported that the major use in the United States today, whether measured by intake or by loss to the atmosphere is irrigation. By the year 2030, in northwestern Oklahoma, municipal and industrial use of water is estimated to total 57,000 acre-feet of water, while irrigation use was estimated to be 1,546,200 acre-feet annually (Oklahoma Water Resources Board, 1975). Water used for irrigation purposes account for almost 90 percent of all water used in the western United States (Ruttan, 1965, p.2). Irrigation for agriculture has been the main cause of the groundwater depletion in arid lands (Bowden, 1977, p.131).

The Oklahoma Water Resources Board (1975) projected the demand for irrigation water in Oklahoma will be about 3.7 million acre-feet annually by 2020. This would be an increase of almost 300 percent. Compared to a national increase of 40 to 60 percent for irrigation water, Oklahoma's irrigation water demand will be much greater.

Municipal

Of all municipal uses yard watering uses the most. In a year's time yard watering accounts for 35 percent of municipal water usage, and this demand is usually during a short time span when water is less available (Oklahoma Water Resources Board, 1980).

Within the home we use the greatest amount of water in home appliances, i.e. luxury items that we have come to believe are essential for daily living. These appliances are flush toilets, dishwashers, and garbage disposals (Sunday Oklahoman, 1984).

An average family of four uses approximately 233 gallons of water each day, with 74 percent of the usage occurring in the bathroom. Of all the house fixtures, toilets use more water than any other, consuming about 40 percent of all water used indoors. Thirty four percent of water consumed in the house is used for bathing and of this 60 percent is used in the shower. Washing machines and dishwaters make up the remaining 26 percent of house use (Oklahoma Water Resources Board, 1980).

Industrial

In Oklahoma the greatest use of water by industry is for dissipation of excess heat. This cooling process consumes water through evaporation (Oklahoma Water Resources Board, 1980). Industrial use of water at present accounts for 4 percent of water used within the state of Oklahoma (Sunday Oklahoman, 1983).

Energy

Under this heading water is considered for producing power (electricity) and the drilling of oil. Electricity producing companies in Oklahoma usually build a reservoir to hold the water they need for cooling their turbines. Oil producers generally utilize whatever is at hand. Sometimes they come into direct conflict with other users of water. Presently Mobile Oil is trying to acquire rights to a quantity of Ogallala aquifer water for secondary oil recovery against western Oklahoma farmers wishes (Daily Oklahoman, 1984). The total amount of water used in Oklahoma for energy purposes is 17 percent of the total water usage.

Water Supplies--Eastern vs Western Oklahoma

Eastern Oklahoma has an abundance of quality water. Western Oklahoma does not. Due to lack of available stream water, and the presence of an exceptional aquifer, ground water development is greatest in the west, where it is used for irrigation, municipal and domestic purposes. Eastern Oklahoma utilizes ground water only in small towns and by rural homeowners due to the abundance of surface water supplies (Oklahoma Water Resources Board, 1983).

On an average, eastern Oklahoma receives more than twice the amount of precipitation than the west--up to 56 inches a year. As a result, eastern Oklahoma also possesses more of the state's lakes, rivers, and streams.

Western Oklahoma has about as many days of drought each year as they have days moisture. Southwestern and west central Oklahoma are constantly experiencing moderate droughts, always in need of more water then the rainfall and snow can deliver (The Daily Oklahoman/Times, 1983).

A plan to transfer water from the east to the west, was accepted in 1981 by the Oklahoma Legislature. This part of the statewide water program has been opposed because of its $11 billion dollar cost, and because eastern Oklahomans do not want their water going to the west. There is also a fear that the two massive pipelines that make up the transfer system would deplete southeastern municipal and industrial water supplies and cause further downturns in the economy of an already depressed area (The Daily Oklahoman/Times, 1983). This situation demonstrates how a state can have enough water for its needs, but Nature distributes it unevenly, therefore we must work within its limits.

Degradation of Oklahoma's Water Resources

"Till taught by pain, men really know not what good water's worth." - Byron

All of man's physical activities, including just being alive, produce wastes. Our knowledge of man's prehistory depends almost exclusively on his ancient wastes from mounds or caves. Even tillage results in increased sediment to the streams. Today there are many forms of waste produced in unending and staggering quantities (Wollman and Bonem, 1971). Pollution ranges from human sewage, animal wastes, wood pulp and thousands of kinds of industrial wastes in many forms: soluble chemicals, suspended solids or immiscible liquids. Waste heat carried by water from power cooling towers and air conditioners poses an increasingly serious problem (Colin and Sall, 1969).

Maxwell (1960) states, "The supply of usable water is always a function of total pure water versus waste." Obviously we cannot use all of the remaining three quarters of our available water to expand our economy. Many of our streams are so laden with waste that any increased concentration is intolerable. We are living in our own filth. Our rivers and streams used to be contaminated with levels of pollution that the natural system could purify. Now they are garbage dumps containing raw sewage, scrap paper, ammonia compounds, toxic chemicals, pesticides, oil and grease that the natural system cannot cleanse itself (Sheets,1981; Boriako,1985).

Water is particularly vulnerable to waste pollution. It is a good solvent and, flowing, provides an easy and cheap means of transportation of waste material. It flows by gravity without extra expense for energy, carrying most of man's waste along on a relatively free ride. Not only does it carry away that with which it is directly loaded; but, running over the ground surface and penetrating through the soil, it seeks out and voluntarily flushes away other wastes as well (King, 1959).

Water quality is just as important as water quantity. Geology, climate, rural and urban development, wastewater treatment and disposal practices all have a direct influence on Oklahoma's water quality. As Oklahoma's population grows, water quality within the state can be expected to be degraded further by increases in the size of municipalities, more industries, more intensive agriculture practices, and so on (Oklahoma Water Resources Board, 1980).

Man-made pollution within the state is primarily due to the influx of industries as well as people. Industry many times discharges pollution in excess of their permit quotas and therefore overburden surface waters. When oil and gas are produced, brine is released in conjunction with production. This brine then is a contributor to the pollution of Oklahoma's streams and ground water. Oil produced in new fields produce little to no brine, but those wells nearing depletion can produce up to 100 barrels of brine for every barrel of oil produced. Oklahoma's oil fields on the whole are old and nearing depletion. Other than depletion, exploration for oil and gas have a direct affect on Oklahoma's ground water. This affect is paramount in western Oklahoma where they are extremely dependent on ground water (Oklahoma Water Resources Board, 1980).

Eastern Oklahoma produces coal which is a water intensive process. The water used in this process becomes very polluted which in turn seriously endangers the region's lakes and streams due to improper disposal.

In addition, large amounts of pollution due to municipalities add to the increased pollution of our water resources. The bulk of the damaging effluents are the result of inadequate sewage treatment procedures.

Many of Oklahoma's smaller communities are not financially able to acquire and maintain a proper treatment system. The use of tertiary treatment plants would be a great enhancement to Oklahoma's water quality due to pollution reduction.

Chemicals used by agriculture and urbanites for various reasons are a constant source of xenobiotics and nonpoint pollution. As the natural fertility of the earth decreases, inordinant amounts of chemical fertilizers are used, more than can be utilized or assimilated by the earth. This excess then proceeds to streams and ground water systems. Western Oklahoma's already meager water supplies are being endangered by nitrates and chlorides by just this process.

Environmental Laws Affecting Oklahoma's Water Resources

Oklahoma's environmental regulations are directly correlated to federal environmental regulations. A brief description of the environmental regulatory history of the federal government begins at the turn of the century and precedes to the current organizations and laws today. At the turn of the century correcting water pollution was aimed at controlling waterborne infectious diseases, which included removal of solids, disinfection and removal of oxygen consuming substances (Environmental Reporter, 1972). A few decades later, Riparian Rights ruled in the eastern states and after a few more decades Prior Appropriations ruled in the western states (Environmental Reporter, 1972). Oklahoma has a combination of both Riparian and Prior Appropriations laws. The role of the federal government concerning the environment was established first in the River and Harbor Act of 1899. This act provides for navigability of rivers and harbors, which were to be free from obstructionable materials as is recorded in section 10 of the Act (Environmental Reporter, 1972). Later, this act would become known as the Refuse Act when amended. Section 13 of the Refuse Act, forbids

> the discharge of any refuse matter of any kind (other than that flowing from streets and sewers in a liquid state) into navigable water" (Schoenbaum, 1982, pg. 32).

This act since its beginning has been important, and is still a force in legislative laws today.

Other acts established after the 1900's started to give the federal government more powers for regulating the environment. The Public Health Service Act of 1912, the Oil Pollution Act of 1924, and the Water Pollution Control Act of 1948 all started to give the federal government more room for operations by expanding the statutory definition and proclaimed that pollution was best dealt with on a local level with federal government assistance (Environmental Reporter, 1972). The Federal Water Pollution Control Act of 1956 was the first comprehensive legislation on a permanent nature which was administered by the surgeon general of the Public Health Service, and later under the supervision of the Secretary of Health (Environmental Reporter, 1972). The act was administered by the secretary of HEW by a 1961 amendment. This act was followed by the Water Quality Act of 1965, which called for each state to establish water quality criteria, and by 1967, all 50 states had adopted water quality criteria (Environmental Reporter, 1972). In 1966, the Clean Water Restoration Act was established to help build sewage treatment plants, and to provide research through federal appropriations (Environmental Reporter, 1972). On January 1, 1970, the National Environmental Policy Act became law, which established a national policy on the environment and created the Council on Environmental Quality in the executive office (Environmental Reporter, 1972). This act further called for a detailed statement concerning the environment and adverse impacts of action, alternatives to the proposed action, the relationship between short and long term used, and any irreversible commitment of resources involved (Environmental Reporter, 1972). Then, on December 2, 1970, the Environmental Protection Agency (EPA) was born. The EPA had the responsibility to establish and enforce standards, monitor and analyze the environment, conduct research and demonstrations, and assist state and local government pollution control programs, administer the federal programs dealing with air pollution, water pollution, solid wastes disposal, pesticide regulations, noise, and environmental radiation. On December 23, 1970, a new program was announced to control water pollution from industrial sources through the permit authority in the Refuse Act of 1899 (Environmental Reporter, 1972).

This brief history, up to the 1970's has demonstrated that an awareness to protect the environment from toxic, chemical, and other types of pollution was in store. And further, the recognition that the federal government has the responsibility to assist state and local government with appropriations to control toxic discharges into America's lakes, rivers, and streams.

The 1972 Federal Water Pollution Control Act (FWPCA) kept five basic structures from the original Act that improved the FWPCA. The first provision established nationally uniform industrial effluent limitations based on best practicable technology, to be achieved by 1977 and best available technology to be achieved by 1983. These limitations are based upon economic and technological capabilities of each industry as set by EPA. The second provision required special controls over severely toxic pollutants. The third provision required National Pollutant Discharge Elimination System permits for all point sources of pollution, providing the first major direct enforcement procedure against polluters. The fourth provision required national effluent limitations for municipal discharges and provided for an expanded federal program of financial assistance to local governments for planning and construction of waste water treatment works. The final provision required a comprehensive river basin and regional water quality planning for both point and nonpoint sources of pollution.

The 1977 amendment to the FWPCA Act was established in response to new demands and solutions. The 1977 amendment set forth long-term authorization of appropriations and grants and explicitly defined the roles of the different levels of government and responsibilities. It also applied to the needs and problems of small communities, rural areas, and agriculture. The 1977 Act was in response to the realization that dangerous toxic polluting was going on in many different forms from PCB's and carbon tetrachloride to oil spills. Many of the toxic forms of pollutants were adversely affecting human health as well as contaminating the nation's water supply. The realization of the spreading of toxic pollutants across the country led to the 1977 legislation, which further established recycling and reuse of pollution control byproducts (effluent, sludge, nutrients), energy conservation, and multiple use of lands and waters which are components of waste water treatment systems (EPA, 1978).

Principally, the Environmental Protection Agency as well as other federal agencies, including the Department of Health, the Department of Agriculture, and the Department of

Wildlife Conservation, are required to work with the states to establish a feasible and practicable method to combat pollution.

The Safe Drinking Water Act gives the primary responsibility to the State to adopt drinking water standards. Municipalities must comply with the standards. However, variances can be made for water wells as long as the variance does not cause the contaminant level to exceed the maximum capacity of the treatment facility. The Safe Drinking Water Act was established to prevent unreasonable risks to the users of the water and safety to the people for drinking the water. The Toxic Substance Control Act (TSCA) was established to control those toxic substances that present unreasonable risks to the environment and injury to the health of people. The purpose of the TSCA is to make sure toxic substances and mixtures do not present an unreasonable risk of injury to health or the environment. In addition, the administrator was instructed to consider environmental, economic, and social impacts of any action taken to remedy the pollution problem of toxic substances.

The Resource Conservation and Recovery Act (1977) set certain objectives which are to protect human health and the environment, to conserve valuable material, and to produce energy from discarded materials by establishing a cooperative effort between federal and local governments. The Act also prohibits open dumping and regulates the treatment, transportation, storage and disposal practices for hazardous wastes.

These environmental regulations give the state authority to regulate, control, and clean up pollution within its boundaries. The Oklahoma agencies that have the authority to handle pollution matters include the (1) Oklahoma Water Resources Board, (2) Oklahoma State Department of Health and, (3) Department of Wildlife Conservation.

The Oklahoma Water Resources Board (OWRB) is the state agency that oversees the activities of water related and disposal activities of the state. The OWRB has the power and duties to conserve the water of the state and to protect, maintain and improve the quality thereof for public water supplies. It also responsible for the propagation of wildlife, fish, and aquatic life for domestic, agricultural, industrial, recreational and other beneficial uses. The OWRB has the powers and duties to develop comprehensive programs for the prevention, control and abatement of pollution problems; to advise and consult with appropriate state and federal agencies; to accept and administer loans and grants; to encourage, participate in or conduct studies; to collect and disseminate information relating to water pollution; to adopt, modify, or repeal and promulgate and enforce rules effecting the powers and duties of the Board. And the OWRB has the authority to regulate permits for various constructions related to the prevention, control, or abatement of pollution in Oklahoma.

The Oklahoma Department of Wildlife Conservation has the authority through the commission to restore and manage, to provide research, and to formulate and adopt plans for wildlife restoration projects.

The Oklahoma State Department of Health, through the State Commissioner of Health is authorized to make investigation, inquiries and studies concerning diseases and probable high incidents of mortality; to advise state and local governments on matters pertaining to health, sanitation and safety.

Environmental regulations were established to protect, prevent, control, and clean up all types of pollution that would affect the aquatic environment. And the environmental regulations give the state the authority to handle the pollution problem if they are capable to handle the problem. The Environmental Protection Agency oversees, mediates, and helps states in their pollution abatement operations.

Conservation

Milton once said," Accuse not Nature! She hath done her part; Do thou but thine." Luther Lee (Slim) Bates always said, "Whatever anyone else can do, you can do at least a little of the same." Embodied in these two quotes are the ideas that people must be thoughtful of our natural resources, and that every little bit conserved is helpful.

No thoughtful person would willfully want to bring about the demise of unique organisms or habitats. Water resource development often has impacts on the use of land by man and by wildlife which extend far beyond the confines of the reservoir. There is a value in having nature, at least in some places, remain unmolested. The purpose of many reservoirs could be fulfilled by other means, such as conservation practices.

Oklahoma's agricultural and metropolitan communities have a critical water problem. Without adequate water supplies for irrigation, our farmers would have smaller crop yields which would result in lower profits. Without adequate water supplies industry would not function. There are measures, however, which if implemented could alleviate the present water problems. These measures consist of the following two types: (1) structural/technological and (2) nonstructural (Francko, 1983). Structural/technological consists of two divergent thoughts with structural being expensive. Energy intensive projects such as the cross state water conveyance system and reservoir construction, while technological deals more with devices of conservation. With technological conservation measures you consume water more efficiently using low flow toilets, low flow shower heads, domestic wastewater recycling systems and trickle irrigation systems. (Francko, 1983).

The second water problem solving technique is the nonstructural. No physical structures are built! Education is the key. Attitudes and behavior modification of the water consumers are promoted thereby enhancing conservative utilization of our water resources.

Attitudes Concerning Water Resources

Chief Seattle once said,

> Whatever befalls the earth befalls the sons of the earth. Man did not weave the web of life; he is merely a strand in it. Whatever he does to the web, he does to himself... (Mother Earth News, 1985, pg. 6)

A proper mindset, or attitude, concerning the earth's natural resources is essential for survival.

Harry, Gale, and Hendee (1969) examined the link between conservationists' attitudes and social structure and compared the characteristics and involvement of conservationists and nonconservationists in a large outdoor activity voluntary association in the Pacific Northwest. As hypothesized, the conservationists and nonconservationists differed on several variables. It was found that conservationists were somewhat older, more highly educated, and held higher status occupations than did nonconservationists in the general populace. Also conservationists tended to specialize in the types of associations and organizations which they joined, and within those memberships, they tended to participate more actively in the formal organization structure of those groups. Higher education and conservation of resources insinuates a correlation between knowledge and conservation attitudes and practices.

Investigations as to what extent the public in Montgomery County, Virginia perceived water as a problem, and what action the public thought should be taken to remedy such problems, were the subject of a 1969 study by Ibsen and Ballweg. Some of the significant findings of that study include: males were more aware of both water resource problems and possible solutions than were females; the younger, more highly educated and higher income persons were cognizant of both water resource problems and potential solutions; and television was reported as the most common source of communications media about water resource problems (Ibsen and Ballweg, 1969).

In the late 1960s statewide surveys were conducted in Wisconsin to discover what type of persons expressed concern about environmental issues and problems and why these persons were concerned (Buttel and Flinn, 1969). The research investigated the relationships between the socioeconomic characteristics (education, income, occupation, place of residence, and political identification) and environmental concern. These research findings supported earlier research findings (Hendee, 1968) that urban oriented persons holding occupations not involving direct exploitation of the natural environment were more likely to perceive environmental problems and subsequently support environmental movements. Buttel and Flinn discovered:

> The rural farm grouping tended in both years to be much less concerned with environmental problems than did rural nonfarm and urban aggregates. (pp. 64-65)

The research findings corroborated the findings of other earlier studies in that political identification had no direct association with concern with pollution. However, the findings did reveal that low educational level Democrats, who typically are the semi- or unskilled workers that that depend upon the manufacturing processes, were less concerned with pollution than Republicans or Independents. But, the highly educated Democrats were more likely to support the environmental movement than were either Republicans or Independents of the same educational level.

A study done by McPartland (1973), found that support for water conservation was greatest among the people who lived in urban areas, who had the most formal education, and who were under 55 years of age; the least support came from people who were directly involved in farming, above age 55, and the least educated. Education had a positive relationship with attitudes, while age, income, and other variables seemed to make little difference in rural attitudes.

Knowledge and Attitude Modification

> Serious problems concerning management of water resources face our nation today. Solutions to these problems involve both technology and education. Better management of existing resources and development of new storage and water

> use technologies are essential. However, decisions concerning conservation of water management are ultimately made not by the scientist, engineer, or technical manager, but by the layman and his elected representatives. Responsible management of our water resources requires the support of an informed public. (Amend, 1983, pg. 362)

An informed public is consistently associated with attitude shift. When the public becomes enlightened from a point of meager knowledge to a higher level of awareness the attitude shift is positive. During the water shortages of the late 1970s in California it was found that the public had a positive attitude about water conservation measures and the resulting hardships when informed on the facts of the water problem (California State Department of Water Resources & Education, 1979). A study done by McPartland (1973) showed that education had a positive relationship with attitudes. Positive attitude changes concerning the environment were reported when people became more knowledgeable of the environment (Ramsey and Rickson, 1976). Using the Energy-Environmental simulator to impart information it was found that increased knowledge on the subject resulted in positive attitude changes about energy and the environment (Dunlop, 1979; Cartwright and Heikkinen, 1981). Mills (1984), in a study of the relationship between information and attitude of users and non-users of computerized water resource management simulation, found that in the junior high and high school populations the acquisition of information resulted in positive attitude change.

From these studies we can infer that learning information (knowledge) about a resource has a positive effect on those with low level knowledge.

In summary, we have discussed how water was historically important. The importance of the quality and quantity of water to the economic structure of the state and the lives of the people cannot be stressed enough. The importance of quality water was also emphasized by the plethora of water laws and acts brought to view. Attitudes of people about natural resources and how knowledge of the subject brought about positive attitude change were also discussed. Emphasis should be given to the fact that in all studies the least educated always had the lowest regard for environmental or natural resource concerns.

CHAPTER III

DESIGN AND METHODOLOGY

Introduction

The purpose of this study was to sample Oklahoma's general public and assess their level of water knowledge. The sampling was done by having the participants respond to the survey instrument concerning water resources.

Description of the Sample

There was a need, based on time and available resources, to select a survey site where the researcher could go and in a short period of time receive information from a large number and variety of people. It was decided that one of Oklahoma's state fairs would be appropriate since they have one of the greatest concentrations of people from varied backgrounds (Oklahoma State Fair Board, 1985).

A state fair also provided a better opportunity to have equal representation from both urban and rural groups. The rational for this was that rural people would be there for participation in the traditional fair events and that urban people would be there for entertainment opportunities

(Oklahoma State Fair Board, 1985).

The Tulsa State Fair was selected since it was reputed to have superior rural associated activities and therefore a greater number of rural participants (Tulsa State Fair Board). The greater number of rural participants would allow for a greater opportunity for a more equal number of urban and rural participants.

Oklahoma's Conservation Commission traditionally has a display booth at the Tulsa State Fair. In the fall of 1984 they allowed the researcher to utilize their booth for the survey. The Conservation Commission's booth was located at the interface of the food and fiber exhibits and the boat and car show by one of the main entrances in the Expo building. This location of the booth was hoped to be advantageous in gaining equal responses from urban and rural citizens.

The subjects of this study were adult members of the public attending the 1984 Tulsa State Fair that would stop at the booth and voluntarily take the water resources knowledge survey instrument. A total of 647 members of the general public participated in this study. In addition, a great number of the participants volunteered information about their concerns about the water resources of Oklahoma. Some of the frequently expressed concerns, concerning water quality, the Illinois River, and the Oklahoma state legislators, are covered in Chapter V under the heading, Anecdotal Feedback.

Collection of Data

Construction of the Survey Instrument

Other than anecdotal information the survey instrument was the sole source of data. The process of determining the adequacy of information requested on the survey instrument included five phases. The first was to conduct a thorough ERIC (Educational Resources Information Center) and library search for an existing survey instrument that would be suitable for Oklahoma's citizens. An appropriate survey instrument could not be found. The second phase was to construct a pool of questions from research, review of literature and related studies found in the ERIC and library search. The third phase was to have the questions reviewed by doctoral students in environmental science and science education, which resulted in suggested changes and deletion of some questions. The fourth phase included consultation with the chairman of the writer's doctoral committee. At this time the researcher was advised to proceed with the development of the survey instrument. The fifth was to have N.N. Durham (Oklahoma State University Graduate Dean and Director of the University Center for Water Research) suggest professionals within the University Center for Water Research to review them. Questions that were deemed valid by the professionals were kept in the pool of questions.

Twelve invalid questions were discarded. The resulting pool of 54 questions was then utilized by the author to construct five water knowledge survey instruments consisting of ten questions each. The four validated questions not used because they were similar in nature to questions already utilized in the surveys.

Within the 50 questions used were two sets of two questions which asked for the same information, yet were worded differently. Each one of these four questions was placed on a different survey instrument. This was done to check response patterns to these questions in order to determine if participants were merely guessing or if the questioning was valid. In each instance response rates were very similar. The response rates differed by 2.7 percent correct on one set of questions and 4.4 percent correct on the second.

Design of the Survey Instrument

The water resources knowledge survey instrument consisted of two sections. The first section consisted of collecting nominal demographic data. This data consisted of age ranges (x) 18 years old and below (y) 30 years to 18 years and (z) above 30 years of age. Only two participants were in the (x) group so they were added into the (y) group. Data was also collected on whether the participant was urban or rural. The rural/urban classification was a subjective choice, left up to the participant as done in a similar study in Nebraska (Quinn, 1979). Information concerning state of residence was also collected. All participants were from Oklahoma.

Section two of the survey consisted of the water resources knowledge questions. The questions were stored and displayed on an Apple IIe microcomputer. The participants were asked to choose a number between one and fifty on the microcomputer. When the number was chosen the computer would then randomly call up a set of ten knowledge questions.

Presentation of the Survey Instrument to the Participants

The survey instrument was given on an Apple IIe microcomputer at the Tulsa State Fair in October of 1984 in the Oklahoma Conservation Commission's booth. Microcomputer equipment consisted of a keyboard, disk drive, and television monitor. The microcomputer was set up directly in the middle of the booth space on a table. A chair was placed in front of the microcomputer for participants to utilize while taking the survey. At this point the participants would begin to answer questions on the microcomputer as they appeared on the monitor. Participants that took the survey instrument were volunteers from the general public. The complete dialogue of what was printed on the monitor is in

Appendix A.

Method of Analyzing Data

The water resources survey test items were also answered on the Apple IIe microcomputer. Answers were recorded directly on the microcomputer disc. All responses compiled were broken down into proper groups for interpretation. These groups consisted of (1) urban (2) rural (3) above 30 years of age (4) below 30 years of age (5) urban/above 30 years of age (6) urban/below 30 years of age (7) rural/above 30 years of age and (8) rural/below 30 years of age.

Analyses between groups were done using Student's t-test and frequency of response. The t-test data results were considered for significance at the $p < .05$ level.

In summary, the purpose of this chapter has been to give a general description of the design of the study. Major areas discussed were description of the sample, collection of data, scope and validity of the instrument, and method of analyzing the data.

CHAPTER IV

RESULTS OF THE STUDY AND DISCUSSION

The previous three chapters have been a general introduction to the study, a review of related literature, and a discussions of the design of the study.

This chapter is a presentation of the findings of the study based on the responses to the survey instrument.

Evaluation of the Results

A total of 647 fair goers actively participated in the survey. All survey participants were from Oklahoma. Survey participants were almost evenly divided between urban and rural dwellers--340 urban participants versus 307 rural participants respectively. There was also good representation from the two age groups used in this analysis: 30 years of age and under had 397 participants versus 250 participants over 30 years of age.

The main purpose of this survey was to: (1) obtain a measure of the public's knowledge of water resources in Oklahoma (2) determine which specific group demonstrated superior water resources knowledge and to (3) gain insight as to the kind of knowledge they possess. An analysis was made of the total group scores as well as of comparisons between responses of urban/rural participants, 30 years of age and under/above 30 years of age groups, between like age groups, and between the same urban or rural classifications.

The cognitive portion of the instrument consisted of ten multiple choice questions. Individual scores were recorded as the number of correct responses. The group mean was 4.6 or 46.1 percent of a possible score of ten.

Tables showing comparison of responses are listed in tables in Appendix B.

The mean score for the urban participants was 4.6, or 46.16 percent. Rural participant responses averaged 4.6, or 46.04 percent. The difference between mean scores of each group were found not to be significantly different at the .05 level (Table I, Appendix B).

A similar comparison of the mean scores of participants in the two age groupings is found in Table II.

The mean scores for the above 30 years of age and the 30 years of age and below participants were 5.13 and 4.29, respectively. The difference between the mean scores was found to be significant at the .05 level.

A comparison between urban and rural participants in the above 30 years of age group revealed a mean score for the rural participants of 5.2, or 52.31 percent. Urban participants in this group had a mean score of 5.0, or 50.45

percent. The mean difference was found not significantly different at the .05 level (Table III).

A similar comparison of the mean scores for urban/rural participants 30 years of age and below was done. The results are found in Table IV.

The mean score of the rural participants was 4.2, or 42.90 percent correct. Urban participants had a mean score of 4.3, or 43.01 percent correct. The mean difference was found to be not significantly different at the .05 level.

A comparison was done within the rural grouping between the two age groups as shown in Table V. The mean score for the above 30 years of age group was 5.2, or 52.31 percent. Thirty years of age and below participants had a mean score of 4.2, or 42.90 percent. The mean difference was found to be significant at the .05 level.

A similar comparison of the mean scores was done with the urban participants utilizing the two age groups. The mean score for the above 30 years of age grouping was 5.0, or 50.45 percent. Thirty years of age and below participants had a mean score of 4.3, or 43.01 percent. The mean difference was found to be significant at the .05 level (Table VI).

Based on the results, those who participated in the survey displayed a nominal command of water related facts and figures. Forty-three of the 50 question were answered satisfactory to very well (33% to 91.6% correct).

These questions were Nos. 3, 6, 7, 11, 12, 14, 18, 19, 20, 22, 24, 29, 32, 33, 34, 37, 38, 46 and 48. Between 50 and 92 percent of the participants who selected these questions on their survey selected the correct answer. The basis for these percentages is shown in Table VII.

The participants' answers to 24 questions ranged from quite good to less than satisfactory (50% to below 33% correct). These questions were Nos. 2, 4, 5, 8, 10, 13, 15, 16, 17, 21, 25, 26, 27, 28, 30, 31, 35, 36, 39, 40, 41, 45, 49, and 50. Of the participants who had these questions in their survey, between 27 and 50 percent selected the correct answer. The basis for these percentages is shown in Table VIII.

The seven remaining questions--Nos. 1, 9, 23, 42, 43, 44, and 47--caused survey participants the most problem. More than 75 percent of the answers to these question were <u>in</u>correct, as shown in Table IX. This large percentage of incorrect answers indicates that the public has some misconceptions about particular water topics. It would be helpful, therefore, to take a closer look at these seven questions, to examine the answers most often given. The percent correct response has been placed to the right of the possible choices, and the asterisk denotes the correct answer.

<u>Question Number 1:</u> What percentage of the annual precipitation in Oklahoma falls during the growing season (April-September)?

(A) 30-40 percent (34.3%)

*(B) 50-60 percent (41.2%)

(C) 70-80 percent (21.3%)

(D) 80-90 percent (3.0%)

One hundred and thirty-one participants had this question in their survey. Answer (B) was the most popular answer with 54 (41 percent) participants responding with it. Answer (A) was the second most popular answer with 45 participants responding with it. Answer (C), the correct answer, received only 28 responses out of 131 for a performance rating of 21 percent. Answer (D) received the fewest responses with only four participants giving it as the proper response.

Answer (B) was the most popular response to this question. This is probably indicative of the fact that people tend to believe we receive precipitation in fairly even allotments each month. It is possible that the public felt that the months April through September constitute 50 percent of the year therefore we must receive 50 percent of our annual precipitation at this time. This type of participant thinking allows them to take into consideration that July and August are usually quite dry but that is compensated by the fact that April and May are unusually wet.

Question Number 9: During the drought years of the 1930s, Oklahoma as a whole received

(A) only 1/3 of its normal average precipitation (66.4%)

*(B) roughly 85% of its normal average precipitation(6.9%)

(C) 70% of its normal average precipitation(5.3%)

(D) only 1/2 of its normal average precipitation(21.4%)

One hundred and thirty-one people had this question in their survey. Answer (A) was the most popular answer with 88 participants (67 percent) responding with it. Answer (D) was the second most popular answer with 28 participants responding with it. Answer (B), the correct answer, received only nine responses out of 131 responses for a performance rating of 6.8 percent. Answer (C) received the fewest responses with only seven participants choosing it as the correct response.

Only 6.8 percent of the participants who had this question in their survey answered correctly. This means that 87.8 percent of the participants thought that, because the 1930's drought was serious, the decline in average precipitation statewide must have been substantial.

Based on long-term average precipitation figures, Oklahoma is classified as humid in the east and semiarid in the west. Humidity indicates an abundance of water, while semi-arid is indicative of being borderline as far as adequate precipitation for agriculture. Thus, different areas of the state have a different reaction to less than average precipitation. The eastern portion of the state can tolerate a 15 percent decrease in precipitation without much concern. Any decrease of precipitation in the western portion of the state would slip it into a drought condition.

Question Number 23: What civilization vanished from Oklahoma due to a drought?

(A) Washita River Culture(16.5%)

*(B) Spiro Mound Culture (20.3%)

(C) Okie Culture (7.5%)

(D) None have ever vanished due to drought (55.6%)

One hundred and thirty-three participants had this question in their survey. Answer (D) was the most popular answer with 74 participants responding with it for a performance rating of 55.6 percent. Answer (B), the correct answer, was the second most popular answer with only 27 participants responding with it for a performance rating of 20.3 percent. Answer (A) received 22 responses and was the third most popular answer. Answer (C) received the fewest responses with only ten participants out of 133 giving it as the proper answer.

Only 20.3 percent of the participants who had this question in their survey answered correctly. It is possible therefore to assume that people are unaware of the drastic, permanent, effect droughts can cause. People have learned their history about events but not the fact that many of the historical events took place as they did due to natural phenomenon, such as drought. Also, most people in Oklahoma these days think of drought not as a life altering event, but merely as an inconvenience, such as having to remember whether to water their lawns on an odd or even day. People also tend to believe that technology will always be able to bail them out. This technofix mentality is pervasive throughout our society. An example to dispel this idea is the Anusazi Indians of Colorado and Arizona. They lacked adequate rainfall for their crops so they built irrigation canals from another water source to their fields. But the alternate source soon failed. Without a proper water resource technology can only do a limited amount of good.

Question Number 42: The approximate difference in average annual precipitation between northwest Oklahoma and southeast Oklahoma is_________.

(A) six inches(17.9%)

(B) fifteen inches(49.3%)

(C) twenty-four inches(21.6%)

*(D) thirty-eight inches(11.2%)

One hundred and thirty-four participants had this question in their survey. Answer (B) was the most popular answer with 66 participants responding with it for a performance rating of 49.3 percent. Answer (C) was the second most popular response with 29 participants choosing it for a performance rating of 21.6 percent. Answer (A) was the third most popular answer receiving 24 responses for a performance rating of 17.9 percent. Answer (D), the correct response, had only 15 participants choose it out of 134 for a performance rating of 11.1 percent. The range of average annual rainfall in the state of Oklahoma is shown in Figure 1 (Appendix C).

Only 15 participants out of 134 answered this question correctly. It is evident from this question that the participants did not have any grasp of the discrepancy in precipitation between different regions of the state. This unawareness of the vast differences concerning water resources in different regions of the state carries political ramifications. The western portion of the state needs water which the eastern portion possesses. The southeastern portion of the state has an overabundance of water but is a financially depressed area, whereas northwestern Oklahoma is financially well off but lacks proper water supplies. This would make a political difference when and if any water resource question came up for a vote to the people of the state, since the majority of people live within the eastern portion of the state.

Question Number 43: _________ uses the largest quantity of water in and around the home.

(A) toilet flushing (38.8%)

(B) bathing (27.6%)

*(C) yard watering (23.1%)

(D) cleaning (10.5%)

One hundred and thirty-four participants had this question in their survey. Answer (A) was the most popular answer with 52 participants responding with it for a performance rating of 38.8 percent. Answer (B) was the second most popular response with 37 of the participants choosing it for performance rating of 27.6 percent. Answer (C), the correct response, had 31 participants choose it for a performance rating of 23.1 percent. The remaining answer (D) had only 14 participants choose it as the correct answer.

Of the 134 participants who had this question in their survey only 31 (23.1 percent) responded correctly. The participants appear to have answered the question according to what they come into contact with most frequently, giving answers (A) and (B) in order, before the proper response, (C). It was believed that the proper response (yard watering) would have been chosen more readily since it is yard watering that people are asked to curtail on a yearly basis to help conserve our water resources. Apparently the participants must believe that they are asked not to water because of dry weather and not the fact that yard watering uses on inordinate amount of water in a short period of time.

<u>Question Number 44:</u> It takes about _____ gallons of water to produce enough cotton to make one t-shirt.

*(A) 580 gallons (22.4%)

(B) 50 gallons (28.4%)

(C) 125 gallons (35.1%)

(D) 10 gallons (14.1%)

One hundred and thirty-four participants had this question in their survey. Answer (C) was the popular answer with 47 participants giving it as the proper answer for a performance rating of 35.1 percent. Answer (B) was the second most popular response with 38 of the participants choosing it for a performance rating of 28.4 percent. Answer (A), the correct response, had 30 participants choose it as the answer for a performance rating of 22.3 percent. The remaining answer (D) had only 19 chose it for a performance rating of 14.2 percent.

Only 30 participants (22.3 percent) of the 134 who had this question in their survey answered it correctly. This suggests that the majority of the participants do not have any concept of the large quantities of water it takes to supply them with items they take for granted and come into contact with daily such as food, clothing and other goods.

<u>Question Number 47:</u> A permeable area where water can seep rapidly into the aquifer is called a _________.

(A) seepage area (58.2%)

(B) roundup area (8.2%)

*(C) recharge area (20.1%)

(D) water table (13.5%)

One hundred and thirty-four participants had this question in their survey. Answer (A) was the most popular response with 78 participants giving it as the correct answer for a performance rating of 58.2 percent. Answer

(C), the correct response, was the second most popular answer receiving 27 responses for a performance rating of 20.1 percent. Answer (D) was the third most popular response being chosen 18 times for a performance rating of 13.4 percent. The remaining answer (B) had only 11 choose it as the correct answer for a performance rating of 8.2 percent.

Of the 134 participants who had this question in their survey only 27 (20.1 percent) gave the correct response. It is rather obvious that the majority of the participants responded with the answer in which part of the word was used in the question. What this might indicate is that the participants are not familiar with certain water resource related terms. The importance of this lies in the fact that most people get their information on water resources from newspaper articles or television. Without a proper understanding of water resources vocabulary and terminology people will not have a true grasp of water related events or situations. This could lead to apathy and misunderstandings which are detrimental to water resource questions when put before the people of Oklahoma to be acted upon by vote or support.

Responses of Rural vs Urban Participants

The 340 urban participants outscored their 307 rural counterparts in the water resources survey. Participants who classified themselves as urban had the highest number of correct responses to 29 of the 50 questions, while the rural participants had the highest number of correct answers to the remaining 21 questions.

Rural and urban participants also displayed different levels of knowledge on particular water topics. The questions where this difference was most marked were Nos. 4,34,43,48,and 50. These questions and the rural versus urban responses are highlighted in the following section.

Question Number 4: Under natural conditions, the rate at which groundwater moves through an aquifer is roughly

(A) 1 foot per hour

*(B) 1 to 3 feet per day

(C) 500 feet per day

(D) 1 mile per day

Of the 66 rural participants who had this question in their survey, 33 answered correctly, for a performance rating of 50 percent. Only 21 urban participants answered correctly for a performance rating of 32.3 percent.

Fifty percent of the rural participants answered this question correctly, while only 32 percent of the urban participants answered correctly. One possible reason for the superior number of responses from the rural participants is due to the fact that most rural people utilize well water and frequently run low on water at times due to a lot of use in a short span of time, which depletes the water in the surrounding formations. In having to wait for well areas to recharge with water they become aware of the concept that water in an aquifer moves slowly. Urban people on the other hand do not come into such situations in their daily lives, so therefore are less aware of the rate at which underground water moves.

Question Number 34: Oklahoma's early expansion and development was based primarily on the availability of

(A) food

*(B) water

(C) shelter

(D) entertainment

Fifty-eight rural participants had this question in their surveys and 50 responded correctly for a performance rating of 86.2 percent. Seventy-one urban participants had this question in their survey and 47 responded correctly for a performance rating of 66.2 percent.

Actually both groups did quite well on this question, but the rural participants did fair better. Eighty-six percent of the rural participants responded correctly, compared to 66 percent correct responses from the urban participants. Since the survey was known to be a water survey it was expected that this question would have even more correct responses than it did. What the responses suggest is that rural people (believed to closer associated with the environment) seem to be better acquainted with the basic essential requirements for existence.

<u>Question Number 43:</u> ________ uses the largest quantity of water in and around the home.

(A) toilet flushing

(B) bathing

*(C) yard watering

(D) cleaning

On this topic, urban and rural responses differed significantly. Sixty-nine urban participants had this question on their survey with nine responding correctly for a performance rating of 13 percent. Sixty-five rural participants had this question on their survey with 22 responding correctly for performance rating of 34 percent.

A possible conclusion to this discrepancy in performance ratings is that rural Oklahomans are more apt to have experiences in irrigation. This experience allows them to have a better grasp on the large quantities of water that can be used in a short expanse of time.

<u>Question Number 48:</u> Building more reservoirs is not the solution to the problem of municipal water shortage in our region because____________________.

(A) we need our ground water for industry and irrigation

*(B) the quantity of surface water available to fill reservoirs is limited

(C) it is too costly to purify the water pumped from reservoirs

(D) we don't need the noise and water pollution caused by more power boats

Sixty-nine urban participants had this question on their survey with 30 responding correctly for a performance rating of 43 percent. Sixty-five rural participants had this question on their survey with 41 responding correctly for a performance rating of 63 percent.

A possible reason for the superior answering of the rural participants to this question is that rural people are more aware of the availability of natural resources since they deal with them on a daily basis. Or at least rural people are not as isolated from the natural environment as are urban people. Rural people are probably aware, from building ponds on their land, that there are only so many drainage areas to utilize, so quantities are limited. Conversely, most all urban areas are centered around a reservoir, so to them quantity and availability of water are moot points.

<u>Question Number 50:</u> Recycling treated waste water could reduce supply requirements in our larger cities by an additional____.

(A) 10-20 percent

*(B) 25-30 percent

(C) 30-35 percent

(D) 45-50 percent

Sixty-five rural participants had this question on their survey with 33 answering correctly for a performance rating of 51 percent. Sixty-nine urban participants had this question on their survey with 21 answering correctly for a performance rating of 30 percent.

A possible reason for the differences in favor of the rural participants is that most rural homes utilize septic tanks. They therefore are familiar with how many gallons their septic tanks can handle and therefore were able to make a better educated choice than their urban counterparts which have no point of reference.

Age Groups

For 36 of the 50 questions, the 251 participants in the 30 and over age group had a higher percentage of correct answers than did their younger counterparts. The under 30 group, with 346 participants, performed better on the thirteen remaining question. (There was a tie on one question--No.31.) Thus, those in the 30 and over group out performed the younger participants in the survey as a whole. The 30 and over group excelled decisively, on 15 questions: Nos. 1, 6, 7, 10, 11, 12, 15, 16, 20, 24, 26, 30, 38, 44, and 45. With each of the questions, their age group performance rating was between 15.5 and 33.3 percent higher than the younger group.

The 30 and below group excelled decisively on three questions: Nos. 27, 33, and 49. With each of these questions, their age group performance rating was between 18.1 and 25.8 percent higher than the older group. Table X is a comparison of the results from both age groups on all 50 questions used in the survey.

A plausible reason for the superior performance of the thirty and over age group could be that their life experiences, being more extensive, has increased their overall water knowledge.

Results of All Participants

Table XI consists of a list of the responses to all 50 questions ranked in descending order. The main concepts of the top 20 percent of the responses deal with the hydrologic cycle and water chemistry. The lower 20 percent of the responses deal with concepts of distribution of precipitation within Oklahoma and the quantities of water expended in daily routines.

Reasons for this type of response pattern is possibly due to the educational system the participants were associated with. In schools the hydrologic cycle and water chemistry are concepts that are commonly taught. The top 20 percent of correct responses dealt with these concepts. The lower 20 percent of the responses dealt with issues of water that are evidently not present in our educational system.

Appendix D includes a series of 50 bar graphs, one for each question used in the survey. The bars in each graph show the number of people who selected the four possible answers, the correct choice being marked with diagonal lines. The percentage at the top of each bar represents the number of people who selected that answer, divided by the total number of people who answered that question. The overall performance rating for each question is the percentage on top of the bar indicated to be the correct answer. An examination of these graphs gives a good overview of the results from all those who participated in the survey. The average performance rating on all 50 questions by all participants was 46.1 percent. While 46.1 percent is not as good as one would like, it does show an aptitude for water resources above merely guessing.

Comparison to Previous Studies

This research collected results similar to previous water related studies. In the earlier studies done by Mills(1983) and Bates(1982) there was a positive correlation between age and water resource knowledge. This study supports the earlier studies positive correlation between higher age and higher water resource knowledge.

Data collected in this study showed that the participants highest water resource knowledge level dealt with concepts of the hydrologic cycle and water chemistry. These results correlate with findings done by Mills (1977).

CHAPTER V

SUMMARY

This study was concerned with assessing the level of knowledge of the general public concerning various aspects of water resources. This assessment was made via a water resources knowledge survey instrument designed by the author.

The research instrument was bisectional, with one portion comprised of three biographical questions. The remaining portion contained 50 multiple choice questions of which each participant was randomly given a block of ten questions.

Study participants were sub-grouped into urban, rural, above 30 years of age, and 30 years of age and below. These groups were further divided into different combinations(1) urban/above 30 years of age (2) urban/30 years of age and below (3) rural/above 30 years of age (4) rural/30 years of age and below.

Comparisons of cognitive mean scores of the subgroups were statistically analyzed using the Student's t-test at the .05 level of significance. Frequency counts were also done between the different sub-groups on each of the 50 questions in the question pool and were reported as the percent of correct responses (performance rating).

Conclusions

The analyses of data produced evidence to substantiate the following conclusions relative to the level of water resources knowledge of the participating public as measured by the water resource survey instrument:

1. The participants were deficient in water resource knowledge as revealed by the low cognitive mean score of less than 50 percent.

2. Urban and rural participants as a whole had the same level of water resources knowledge.

3. The above 30 years of age grouping was more knowledgeable of water resources than the 30 years old and below grouping.

4. Urban and rural participants above 30 years of age hold the same level of water resource knowledge.

5. Urban and rural participants 30 years of age and below maintain the same level of water resources knowledge.

6. The above 30 years of age rural group was more knowledgeable of water resources than the 30 years of age and below rural group.

7. The above 30 years of age urban group was more knowledgeable of water resources than the 30 years of age and below group.

8. The performance level on these tests were similar to previous studies in that public knowledge levels are low with older subjects scoring higher than younger.

Anecdotal Feedback

While interacting with each participant before or after their taking the water resources survey instrument the researcher found that valuable information was being offered that was not on the survey instrument. Although this information was not a formal part of this study it should be reported since this voluntary information can provide insight to the publics' awareness of water resources. During the week the data was gathered at the fair the following eight items of concern consistently surfaced in discussions:

1. Participants had a definite lack of confidence in Oklahoma's legislative bodies.

2. Participants expressed that they thought the Illinois River is a lost cause due to governmental inadequacy and/or apathy.

3. The majority of the participants expressed opinions that they thought industries should not be given a descending block rate for larger amounts of water used. Rather they would like to see industry charged more as they use more. The general consensus was that this would instill better utilization of water used, leading to conservation of

our water resources.

4. Participants thought that water saving fixtures should become standard specifications for new housing.

5. The participants believed that water leaving a township should not be any worse in quality than when it arrived to the township.

6. Participants were concerned that the state government was more concerned with quality prison programs than quality natural resource programs. The general consensus was that this was due to publicity. It is publicly more embarrassing to show prisoners (law breakers) a little crowded than it is to show a town of citizens (law abiders) without adequate quality water supplies or facilities. The participants seemed extremely incensed that people who break the law are given a higher degree of concern than those who obey the law.

7. Participants expressed a desire to know more about water resources. However, they were not sure about the truth of what they hear on television or read in the papers. They expressed a concern that the news is manipulated and that other information they receive is biased or skewed. The participants expressed that radio, television, and newspapers were good ways to disseminate information but they would just like to have proof that said information was reliable.

8. Participants were unanimous in their belief that

the general populace will not truly worry about water until they go to their tap and water is not available.

In summary, the participants expressed a lack of confidence in the state's governmental bodies to properly handle water problems and questioned their priorities. Also participants have no faith in their information sources or in the general populace to care about water resources until problems arise.

Recommendations

The data would seem to indicate that the general level of knowledge concerning water resource issues is deficient among the participating public regardless of where they reside or their age.

Compensation for this lack of awareness might best be realized by:

1. Water awareness programs made available to schools and communities.

2. An increase in reliable water related information released through public media (i.e., newspapers, television, radio, and various forms of literature).

3. State and university water education consultants made available to schools and other groups.

4. A comprehensive series of water related presentations appropriate for educational television.

5. Cooperative educational efforts by schools,

universities, and water related concerns such as Oklahoma's Water Resources Board, etc.

6. A resource and educational center whose responsibilities would include: the development and dissemination of educational literature, activities and audio-visual materials; water related mini-courses available to teachers as well as other members of the community; providing water education consultants.

7. Educational information disseminated dealing specifically with precipitation patterns within Oklahoma and quantities of water used in daily activities.

There is no doubt the availability and efficient use of water will become increasingly important in a world so dependent on finite water sources. Studies of the type reported here hopefully provide some insight into the level of water knowledge and may act as a starting point towards realizing water sufficiency through increased understanding.

It is recommended future studies be expanded in both scope and sample size.

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APPENDIX A

WATER SURVEY INSTRUMENT

WATER SURVEY INSTRUMENT

Would you please take few moments to take a short quiz concerning water resources in Oklahoma? If so, please enter your first name and press the [return] key.

Name Please?

Thank you NAME for your interest in water resources!

I need some information before we start the quiz. Please answer the following questions by choosing a single letter located to the left of each possible response.

Are you:

X.......Under 18 years of age?

Y.......between 18 and 30 years of age?

Z.......over 30 years of age?

Choice?

Have you lived:

U...within a city limit most of your life?

R...outside a city limit most of your life?

Choice?

Are you a resident of Oklahoma?

Y.....YES

N.....NO

Now,......choose a number between 0 and 51.

Choice?

APPENDIX B

TABLES

TABLE I

T-TEST COMPARISONS OF RURAL AND URBAN PARTICIPANTS

	Number of Participants	Mean of Summed Scores	Standard Deviation	t
Urban	340	4.61	2.01	0.0299
Rural	307	4.60	2.18	

p=0.5000

TABLE II

T-TEST COMPARISON OF AGE GROUPS

	Number of Participants	Mean of Summed Scores	Standard Deviation	t
Above 30	251	5.13	2.35	-1.8897
30 & below	396	4.29	2.05	

p= 0.0292

TABLE III

T-TEST COMPARISON OF URBAN AND RURAL PARTICIPANTS ABOVE 30 YEARS OF AGE

	Number of Participants	Mean Summed Scores	Standard Deviation	t
Rural above 30	106	5.24	2.54	-0.3789
Urban above 30	145	5.04	2.36	

p= 0.3536

TABLE IV

T-TEST COMPARISON OF URBAN AND RURAL PARTICIPANTS
30 YEARS OF AGE AND BELOW

	Number of Participants	Mean of Summed Scores	Standard Deviation	t
Rural 30 & below	201	4.29	2.18	0.0261
Urban 30 & below	195	4.30	2.04	

p= 0.5000

TABLE V

T-TEST COMPARISON OF RURAL PARTICIPANTS ABOVE 30 YEARS OF AGE AND 30 YEARS OF AGE AND BELOW

	Number of Participants	Mean of Summed Scores	Standard Deviation	t
Rural above 30	106	5.23	2.54	1.9838
Rural 30 & below	201	4.29	2.18	

p= 0.0236

TABLE VI

T-TEST COMPARISON OF URBAN PARTICIPANTS ABOVE 30 YEARS OF AGE AND 30 YEARS OF AGE AND BELOW

	Number of Participants	Mean of Summed Scores	Standard Deviation	t
Urban 30 & above	145	5.04	2.36	1.6810
Urban 30 & below	195	4.30	2.04	

$p = 0.0460$

TABLE VII

NINETEEN QUESTIONS WITH A PERFORMANCE RATING HIGHER THAN 50 PERCENT

Question No.	No. of People Who Answered Question	No. of People Who Answered Correctly	Over-all Performance Rating *
3	131	80	61.1%
6	131	74	56.5
7	131	75	57.2
11	117	93	79.4
12	117	86	73.5
14	117	63	53.8
18	117	77	65.8
19	117	86	73.5
20	117	93	79.4
22	133	102	76.6
24	133	86	64.6
29	133	94	70.6
32	132	89	67.4
33	132	93	70.4
34	132	99	75.0
37	132	121	91.6
38	132	81	61.3
46	134	105	78.3
48	134	71	52.9

* Over-all Performance Rating = $\frac{\text{Correct Answers}}{\text{Total Answers}}$ expressed as a percent

TABLE VIII

TWENTY-FOUR QUESTIONS WITH A PERFORMANCE RATING BETWEEN 25 AND 50 PERCENT

Question No.	No. of People Who Answered Question	No. of People Who Answered Correctly	Over-all Performance Rating *
2	131	45	34.3%
4	131	54	41.2
5	131	34	25.9
8	131	52	39.6
10	131	56	42.7
13	117	42	35.8
15	117	51	43.5
16	117	52	44.4
17	117	38	32.4
21	133	45	33.8
25	133	44	33.1
26	133	49	36.8
27	133	40	30.1
28	133	50	37.5
30	133	60	45.1
31	132	44	33.3
35	132	44	33.3
36	132	34	25.7
39	132	54	40.9
40	132	42	31.8
41	134	39	29.1
45	134	67	50.0
49	134	40	29.8
50	134	54	40.2

* Over-all Performance Rating = $\frac{\text{Correct Answers}}{\text{Total Answers}}$ expressed as a percent.

TABLE IX

SEVEN QUESTIONS WITH A PERFORMANCE RATING
OF LESS THAN 25 PERCENT

Question No.	No. of People Who Answered Question	No. of People Who Answered Correctly	Over-all Perfromance Rating*
1	131	28	21.3%
9	131	9	6.8
23	133	27	20.3
42	134	15	11.1
43	134	31	23.1
44	134	30	22.3
47	134	27	20.1

* Over-all Performance Rating = $\frac{\text{Correct Answers}}{\text{Total Answers}}$ expressed as a percent.

TABLE X

A COMPARISON OF RESULTS FROM THE TWO AGE GROUPS USED IN THIS ANALYSIS

Question No.	No. of People Who Answered the Question		No. of People Who Answered Question Correctly		Age Group Performance Rating*	
	Under 30	30 & Over	Under 30	30 & Over	Under 30	30 & Over
1	78	53	11	17	14.1%	32.0%
2	78	53	24	21	30.7	39.6
3	78	53	43	37	55.1	69.8
4	78	53	31	23	39.7	43.3
5	78	53	22	12	28.2	22.6
6	78	53	37	37	47.3	69.8
7	78	53	35	40	44.8	75.4
8	78	53	34	18	43.5	33.9
9	78	53	5	4	6.4	7.5
10	78	53	24	32	30.7	60.3
11	76	41	56	37	73.6	90.2
12	76	41	47	39	61.8	95.1
13	76	41	25	17	32.8	41.4
14	76	41	41	22	53.9	53.6
15	76	41	29	22	38.1	53.6
16	76	41	25	27	32.8	65.8
17	76	41	21	17	27.6	41.[illegible]
18	76	41	47	30	61.8	73.1
19	76	41	55	31	72.3	75.6
20	76	41	55	38	72.3	92.6
21	79	54	25	20	31.6	37.0
22	79	54	60	42	75.9	77.7

Continued.

TABLE X (CONTINUED)

Question No.	No. of People Who Answered the Question		No. of People Who Answered Question Correctly		Age Group Performance Rating*	
	Under 30	30 & Over	Under 30	30 & Over	Under 30	30 & Over
23	79	54	13	14	16.4%	25.9%
24	79	54	46	40	58.2	74.0
25	79	54	30	14	37.9	25.9
26	79	54	23	26	29.1	48.1
27	79	54	32	8	40.5	14.8
28	79	54	30	20	37.9	37.0
29	79	54	59	35	74.6	64.8
30	79	54	29	31	36.7	57.4
31	78	54	26	18	33.3	33.3
32	78	54	48	41	61.5	75.9
33	78	54	61	32	78.2	59.2
34	78	54	58	41	74.3	75.9
35	78	54	24	20	30.7	37.0
36	78	54	21	13	26.9	24.0
37	78	54	67	54	85.8	100.0
38	78	54	42	39	53.8	72.2
39	78	54	28	26	35.8	48.1
40	78	54	22	20	28.2	37.0
41	85	49	20	19	23.5	38.7
42	85	49	6	9	7.0	18.3
43	85	49	23	8	27.0	16.3
44	85	49	11	19	12.9	38.7
45	85	49	33	34	38.8	69.3
46	85	49	68	37	80.0	75.5
47	85	49	13	14	15.2	28.5
48	85	49	41	30	30.7	37.0
49	85	49	31	9	36.4	18.3
50	85	49	36	18	42.3	36.7

$$\text{* Age Group Performance Rating} = \frac{\text{Age Group's Correct Answers}}{\text{Age Group's Total Answers}} \text{ expressed as a percent.}$$

TABLE XI

LIST OF RESPONSES RANKED IN DECENDING ORDER

Question No.	Response %	Question No.	Response %
37.	91.6%	39.	40.9%
11.	79.5%	50.	40.4%
20.	79.5%	8.	39.7%
46.	78.4%	28.	37.6%
22.	76.7%	26.	36.8%
34.	75.0%	13.	35.9%
12.	73.5%	2.	34.3%
19.	73.5%	21.	33.8%
29.	70.7%	31.	33.3%
33.	70.5%	35.	33.3%
32.	67.4%	25.	33.1%
18.	65.8%	17.	32.5%
24.	64.7%	40.	31.8%
38.	61.4%	27.	30.1%
3.	61.1%	49.	29.8%
7.	57.2%	41.	29.1%
6.	56.4%	5.	25.9%

Continued

TABLE XI (CONTINUED)

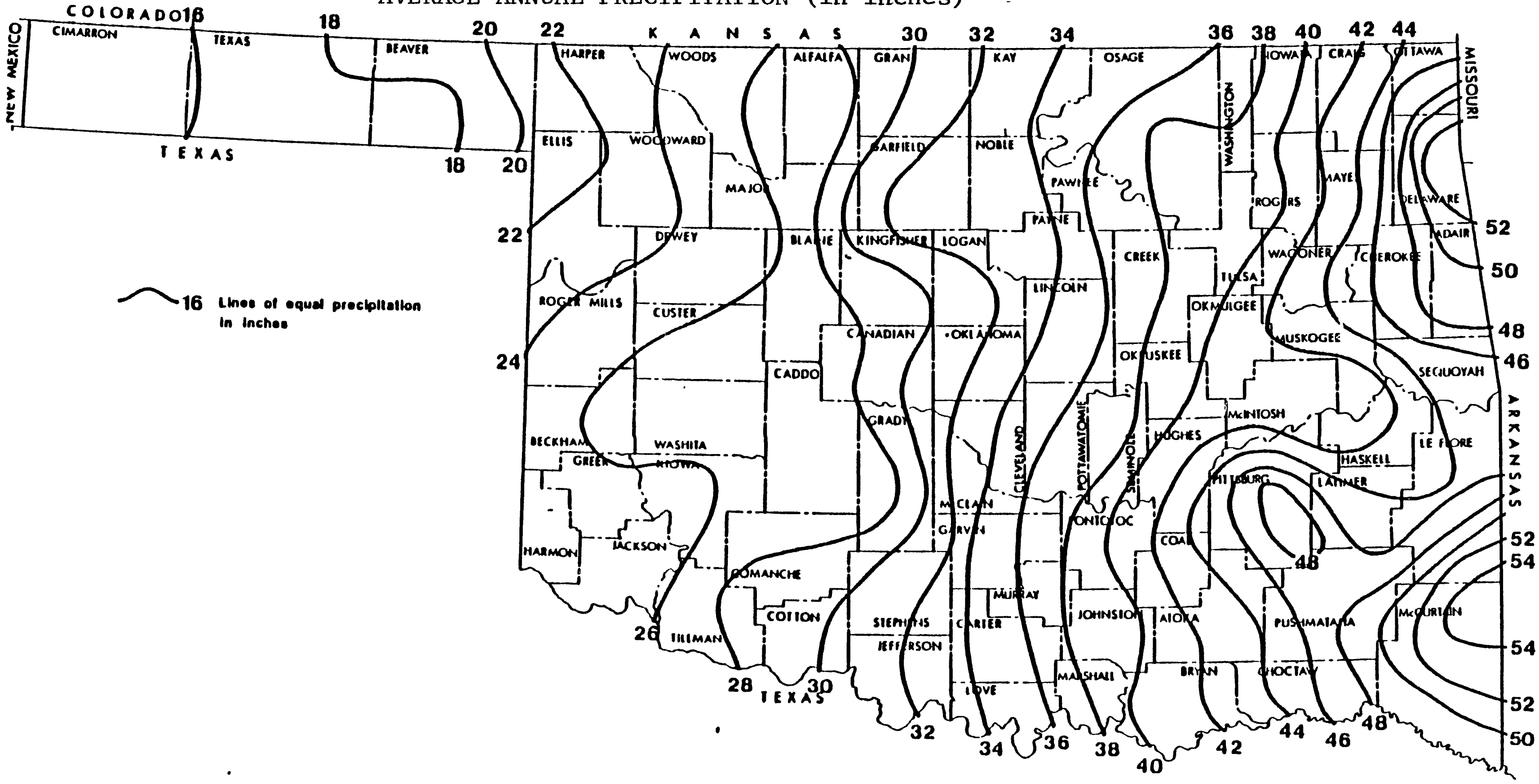
14.	53.8%	36.	25.8%
48.	53.0%	43.	23.1%
45.	50.0%	44.	22.4%
30.	45.1%	1.	21.3%
16.	44.4%	23.	20.3%
15.	43.6%	47.	20.1%
10.	42.7%	42.	11.2%
50.	40.4%	9.	6.9%

APPENDIX C

MAP

FIGURE 1

AVERAGE ANNUAL PRECIPITATION (in inches)



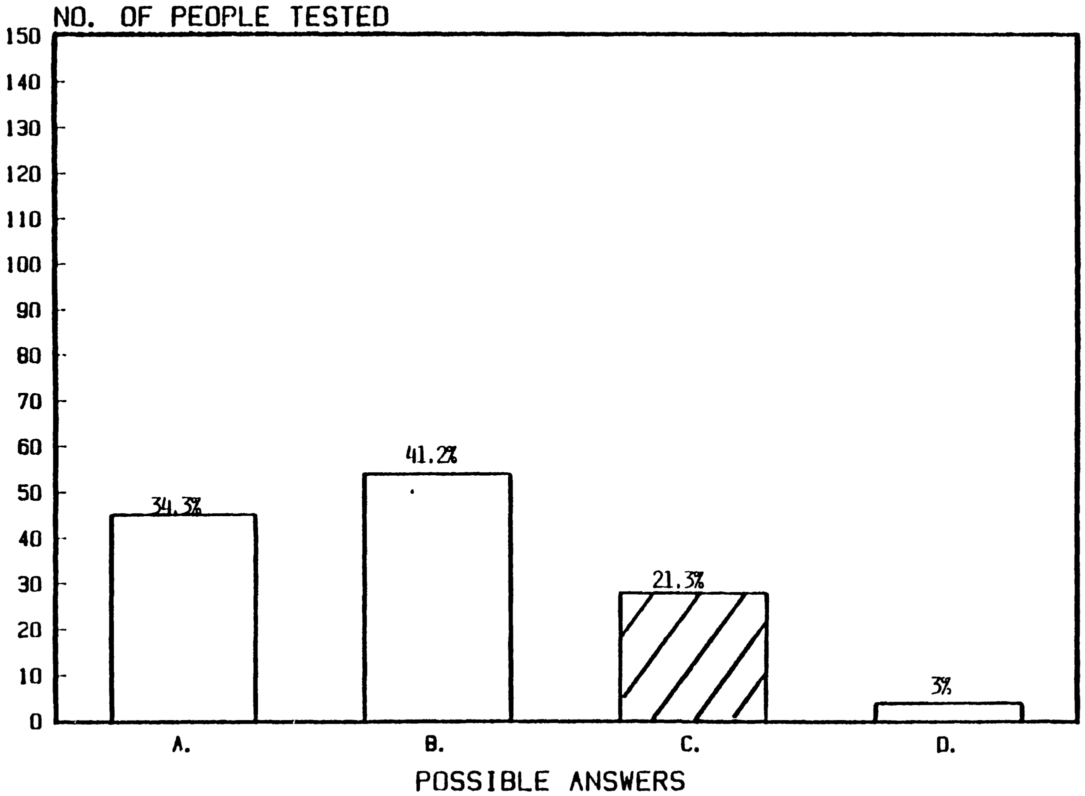
AVERAGE ANNUAL PRECIPITATION (In Inches)
(Period 1970-79)

Data National Oceanic and Atmospheric Administration (1970 79)

APPENDIX D

BAR GRAPHS

QUESTION ONE



No. 1. What percentage of the annual precipitation in Oklahoma falls during the growing season (April-September)?

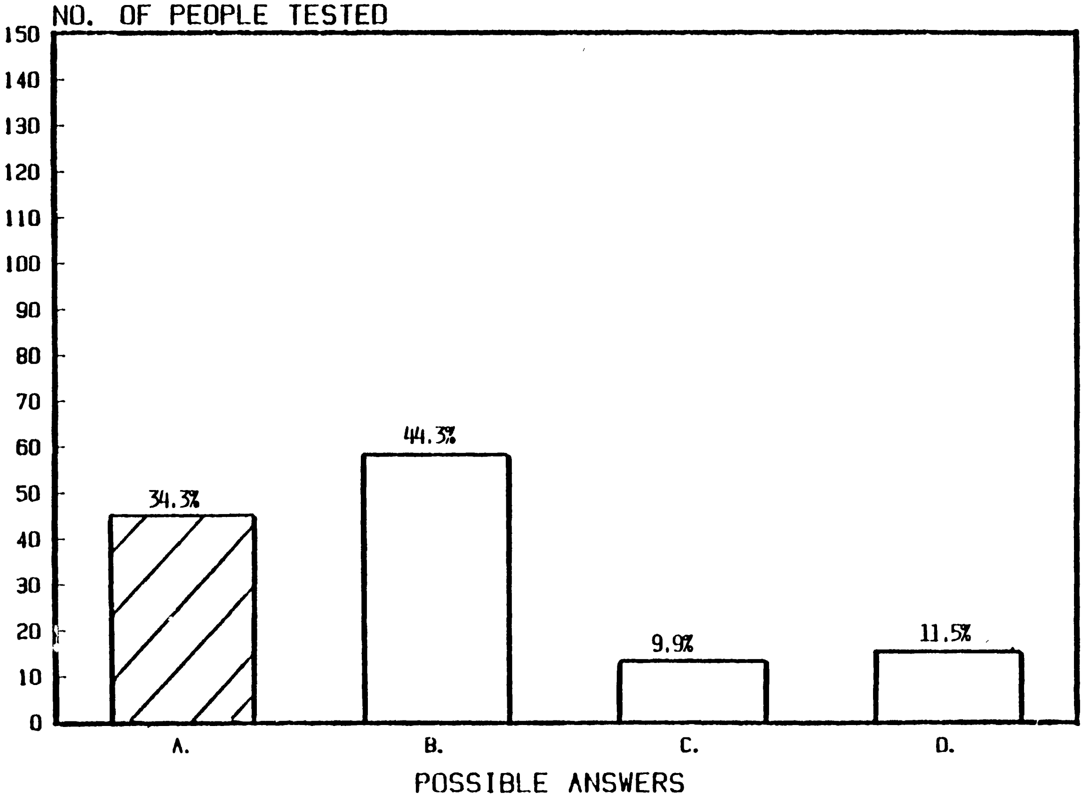
(A) 30-40 percent

(B) 50-60 percent

(C) 70-80 percent

(D) 80-90 percent

QUESTION TWO



No.2. Precipitation varies widely over Oklahoma's different regions. When all these regional variations are averaged together, the overall yearly average precipitation for the entire state is

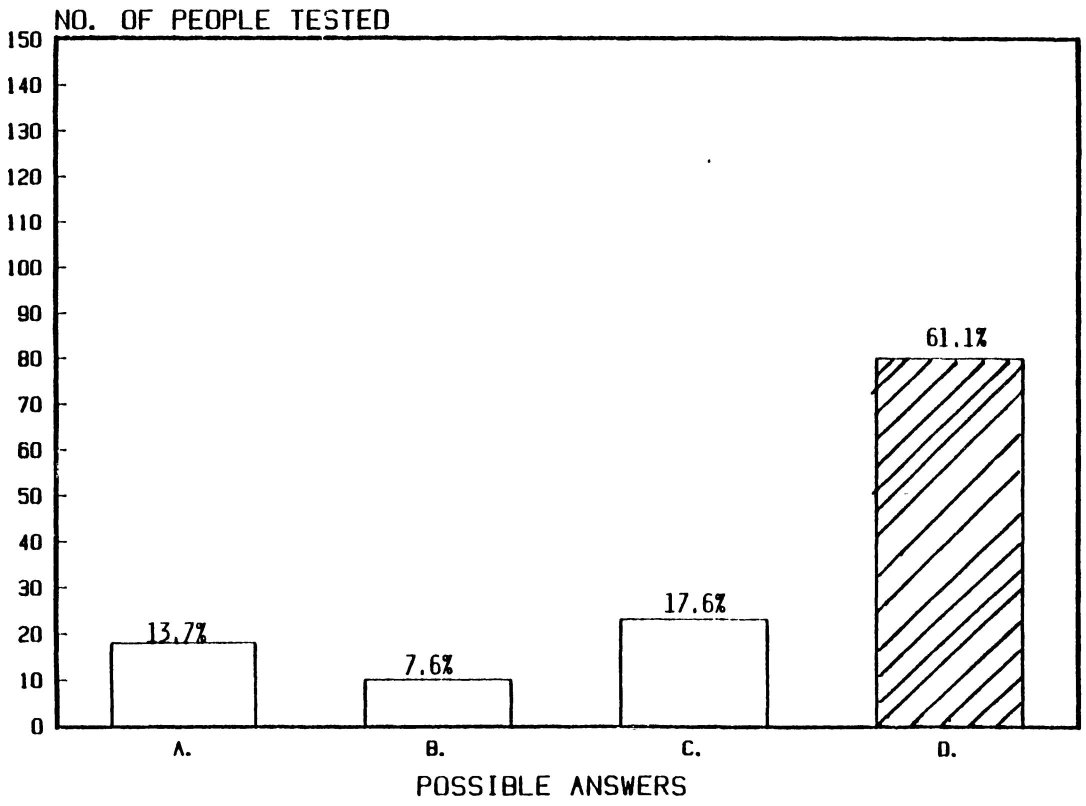
(A) 35 inches

(B) 22 inches

(C) 15 inches

(D) 42 inches

QUESTION THREE



No.3. An aquifer is

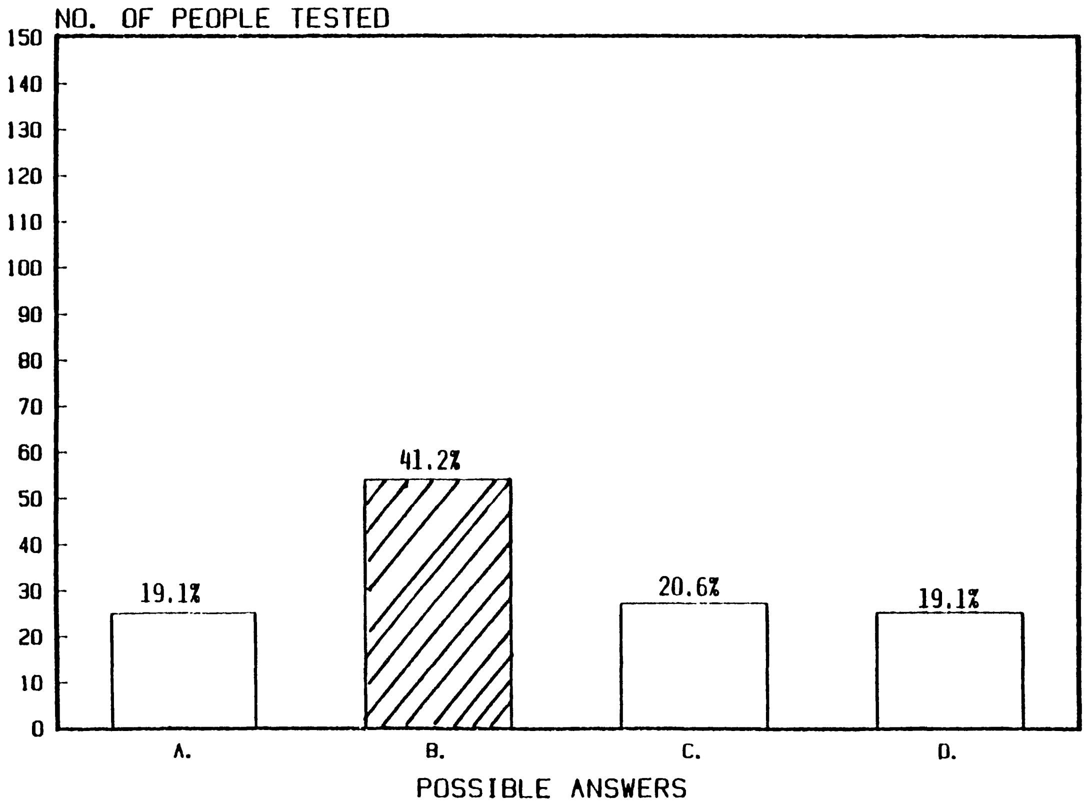
(A) a unit for measuring the quantity of water

(B) a type of well

(C) a type of water meter

(D) a geologic formation capable of yielding significant quantities of water

QUESTION FOUR



No.4. Under natural conditions, the rate at which groundwater moves through an aquifer is roughly

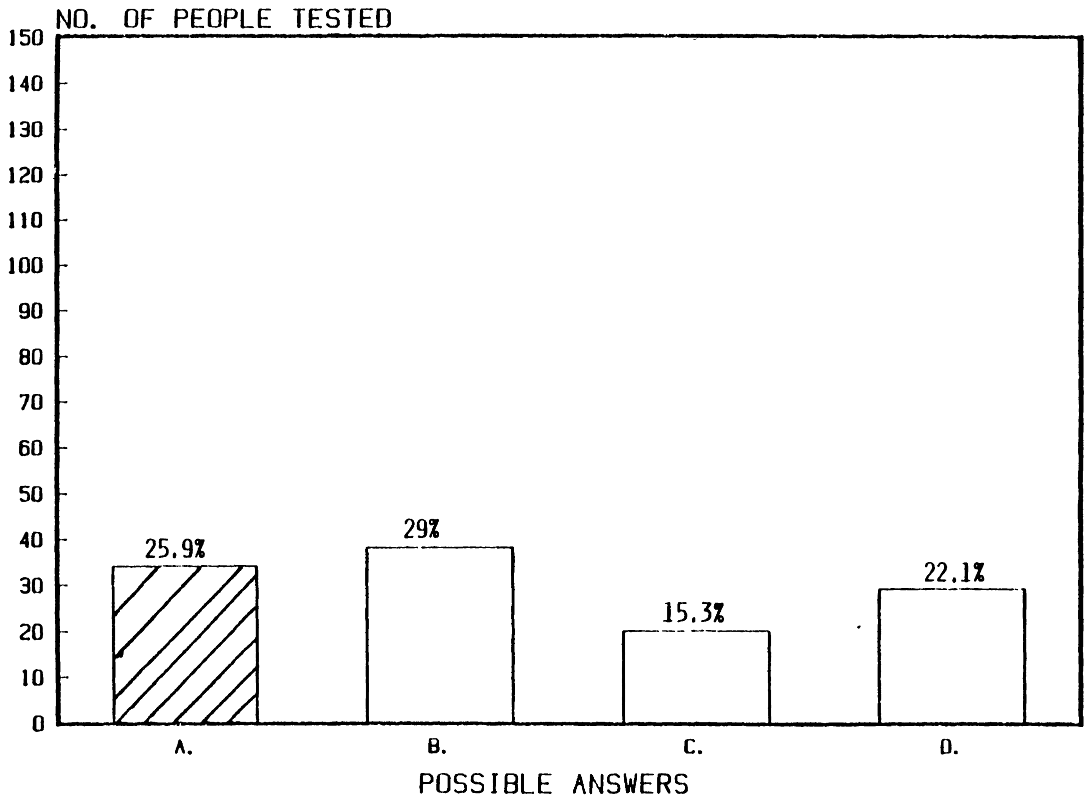
(A) 1 foot per hour

(B) 1 to 3 feet per day

(C) 500 feet per day

(D) 1 mile per day

QUESTION FIVE



What happens to most of Oklahoma's statewide average annual precipitation?

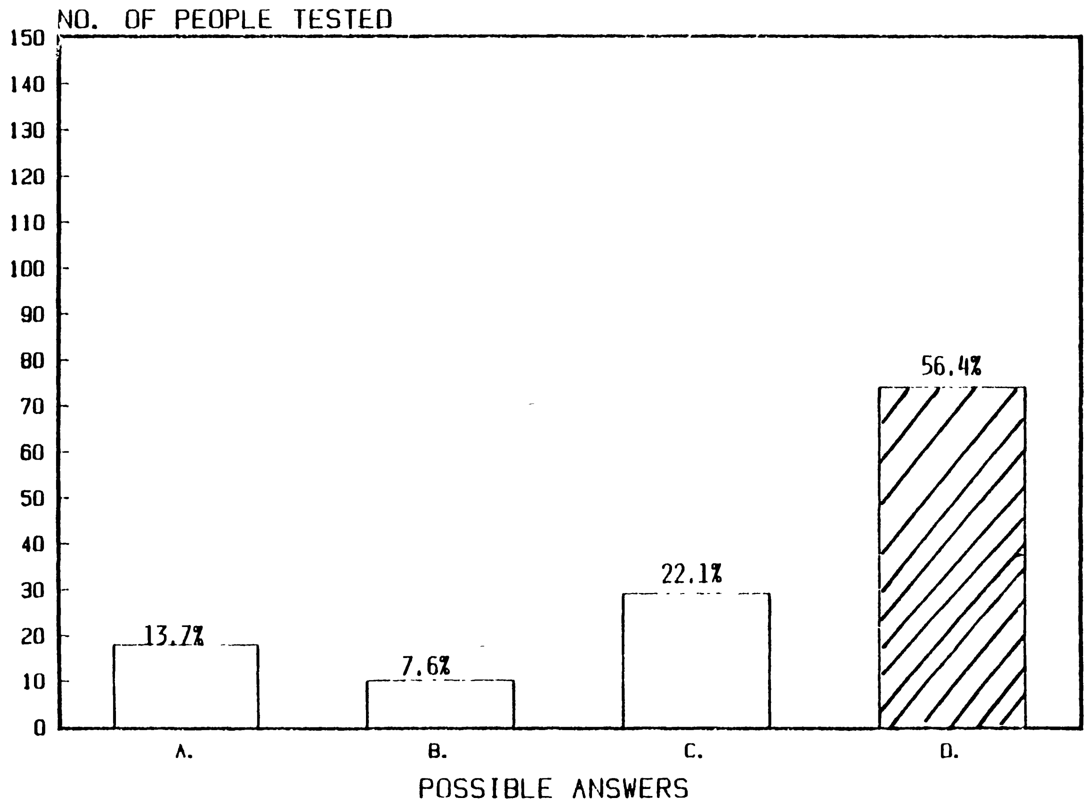
(A) It evaporates

(B) It becomes groundwater

(C) It passes overland into streams

(D) It collects in lakes

QUESTION SIX



No.6. Water in Oklahoma's rivers generally flows toward the

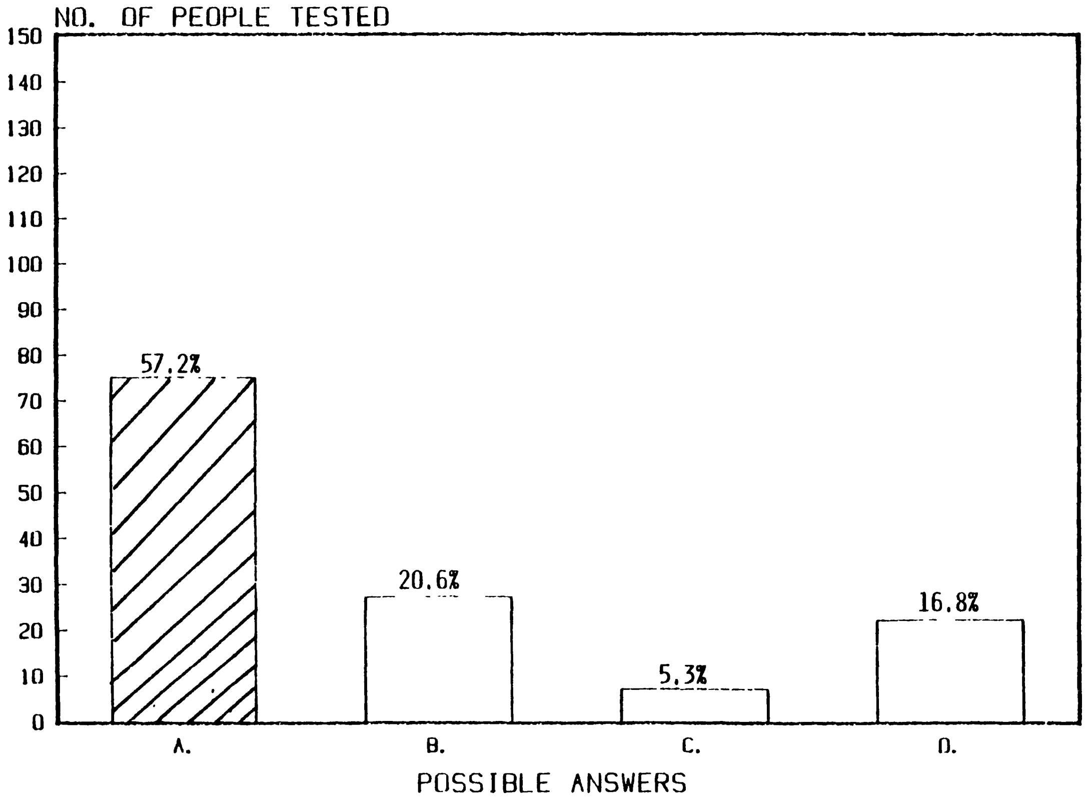
(A) Northeast

(B) Northwest

(C) Southwest

(D) Southeast

QUESTION SEVEN



No.7. Lake Eufaula is a man-made lake located on the

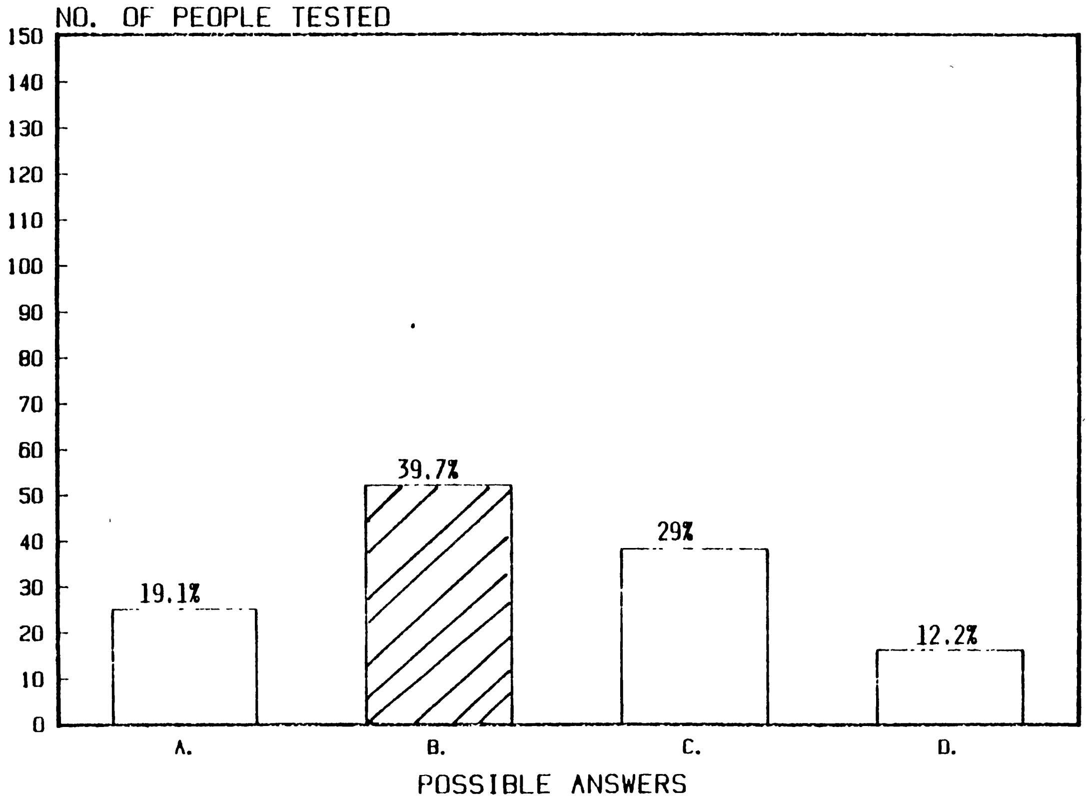
(A) Canadian River

(B) Verdigris River

(C) Caney River

(D) Red River

QUESTION EIGHT



No.8. In an average growing season an acre of irrigated corn consumes approximately

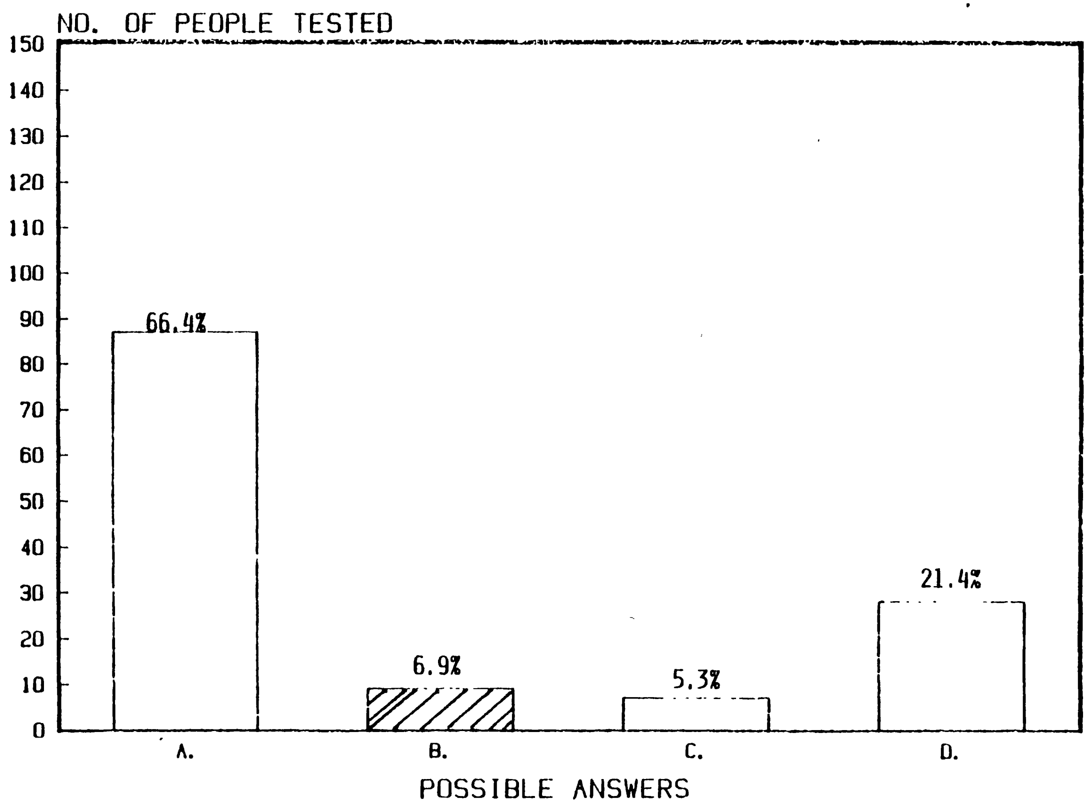
(A) 8 acre-inches of water

(B) 26 acre-inches of water

(C) 95 acre-inches of water

(D) 180 acre-inches of water

QUESTION NINE



No.9. During the drought years of the 1930's, Oklahoma as a whole received

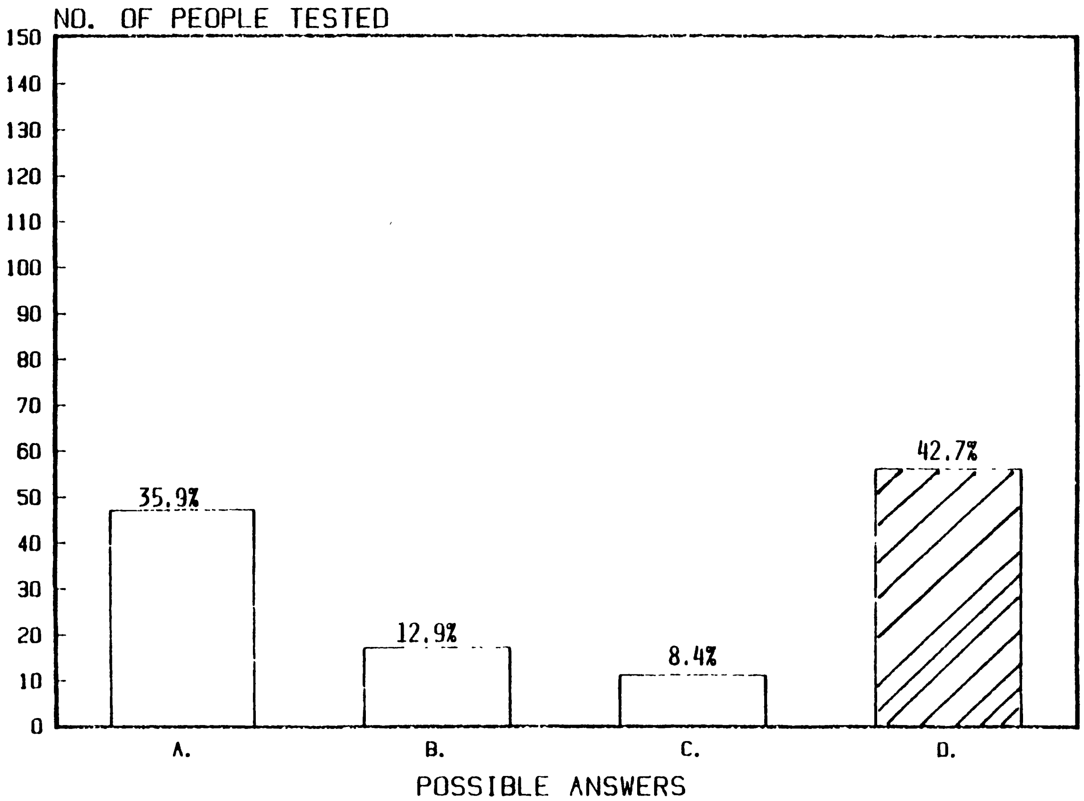
(A) only 1/3 of its normal average precipitation

(B) roughly 85 percent of its normal average precipitation

(C) 70 percent of its normal average precipitation

(D) only 1/2 of its normal average precipitation

QUESTION TEN



No.10. Oklahoma's abundant ground-water supply occurs in

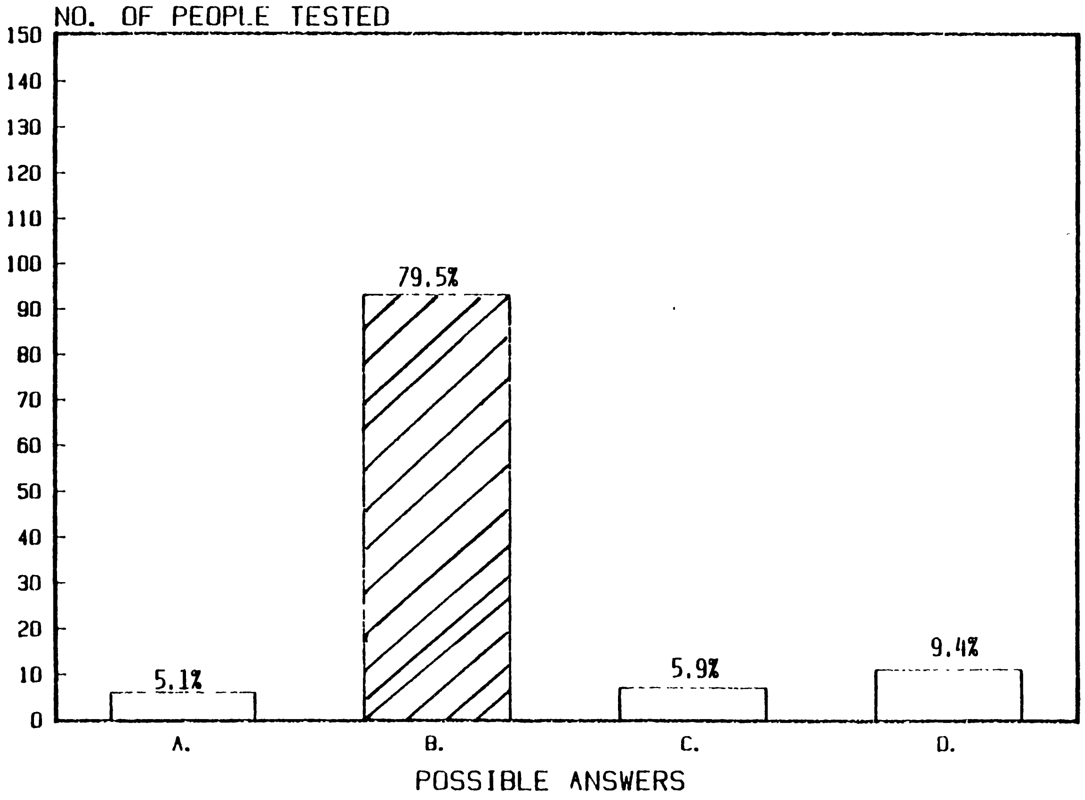
(A) a network of underground rivers

(B) vast underground lakes

(C) intersecting veins in solid rocks

(D) interconnecting spaces between grains of silt, sand and/or gravel

QUESTION ELEVEN



No.11. In what season does Oklahoma, on the whole, receive the most precipitation?

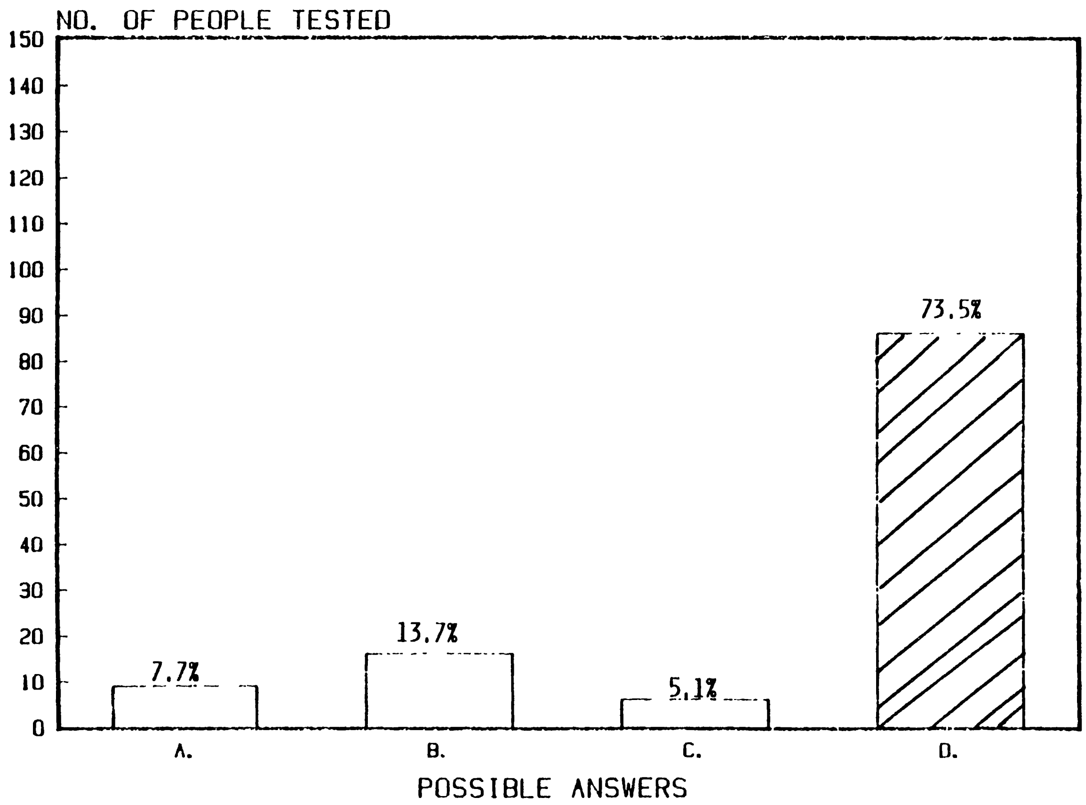
(A) Winter: December, January, and February

(B) Spring: March, April, and May

(C) Summer: June, July, and August

(D) Fall: September, October, and November

QUESTION TWELVE



No.12. Lake Texoma is a man-made lake located on the

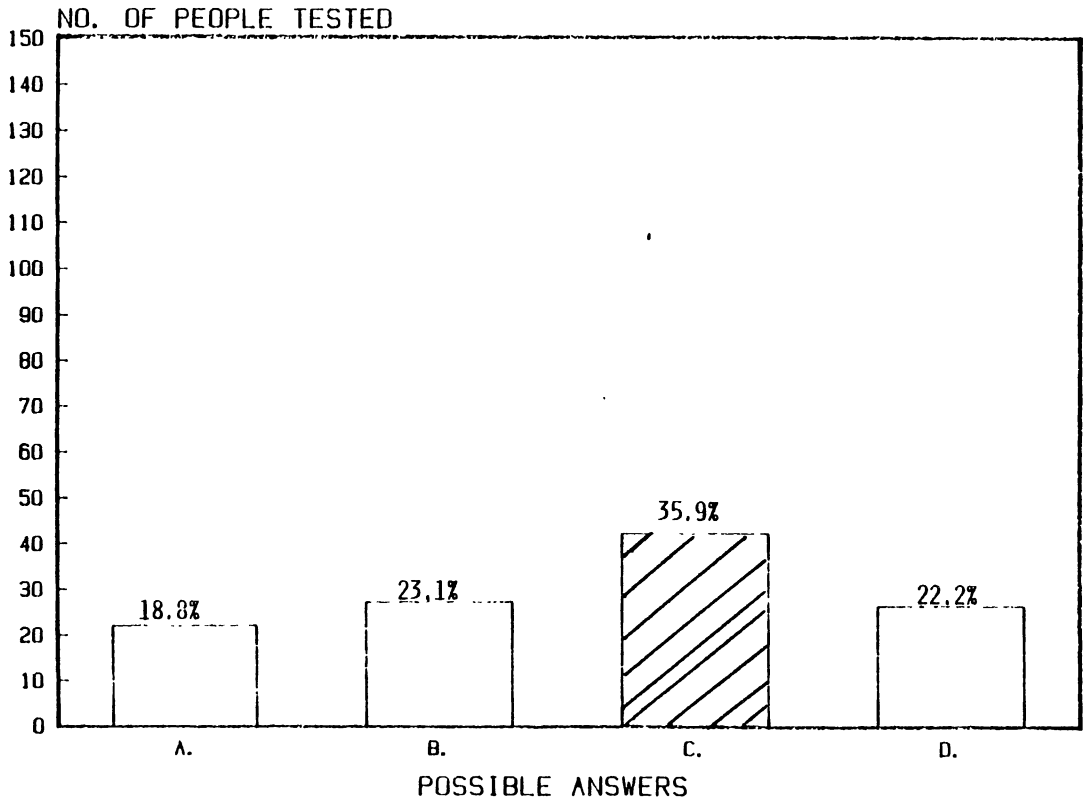
(A) Canadian River

(B) Cimarron River

(C) Verdigris River

(D) Red River

QUESTION THIRTEEN



No. 13. How does a well yield of 1,000 gallons per minute compare to well yield of 1,000 liters per second?

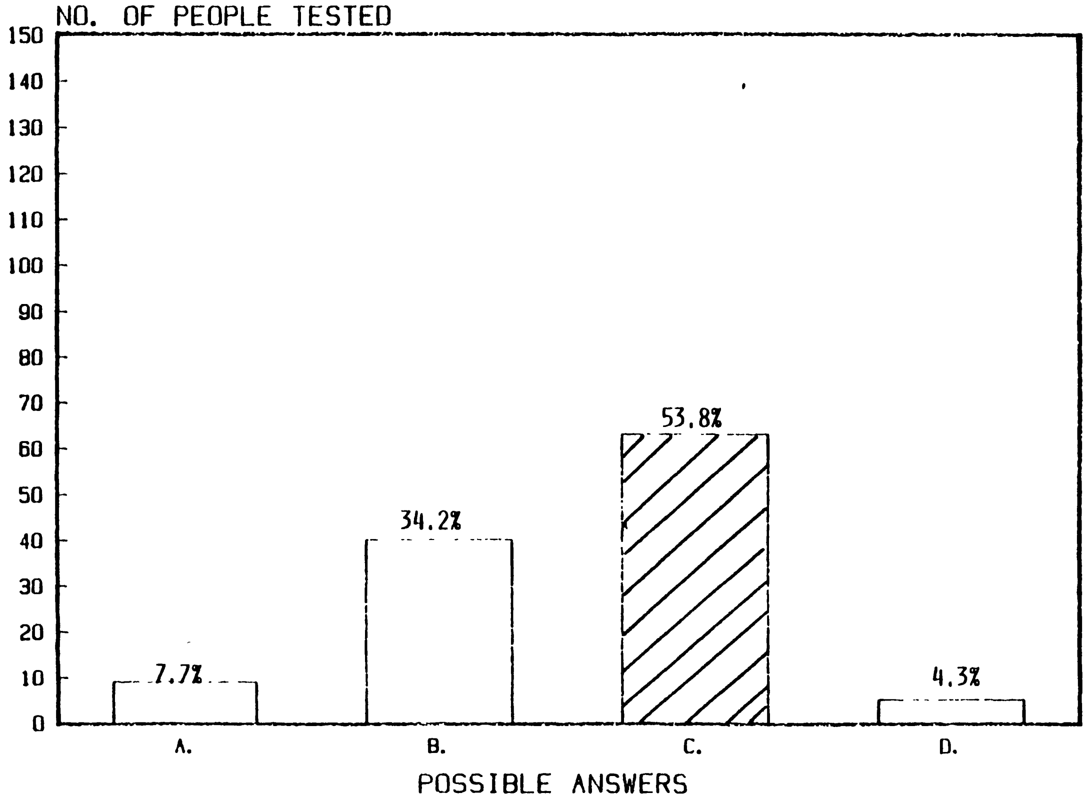
(A) It is the same

(B) It is twice as much

(C) It is many times less

(D) It is many times more

QUESTION FOURTEEN



No.14. Most untreated groundwater in Oklahoma contains

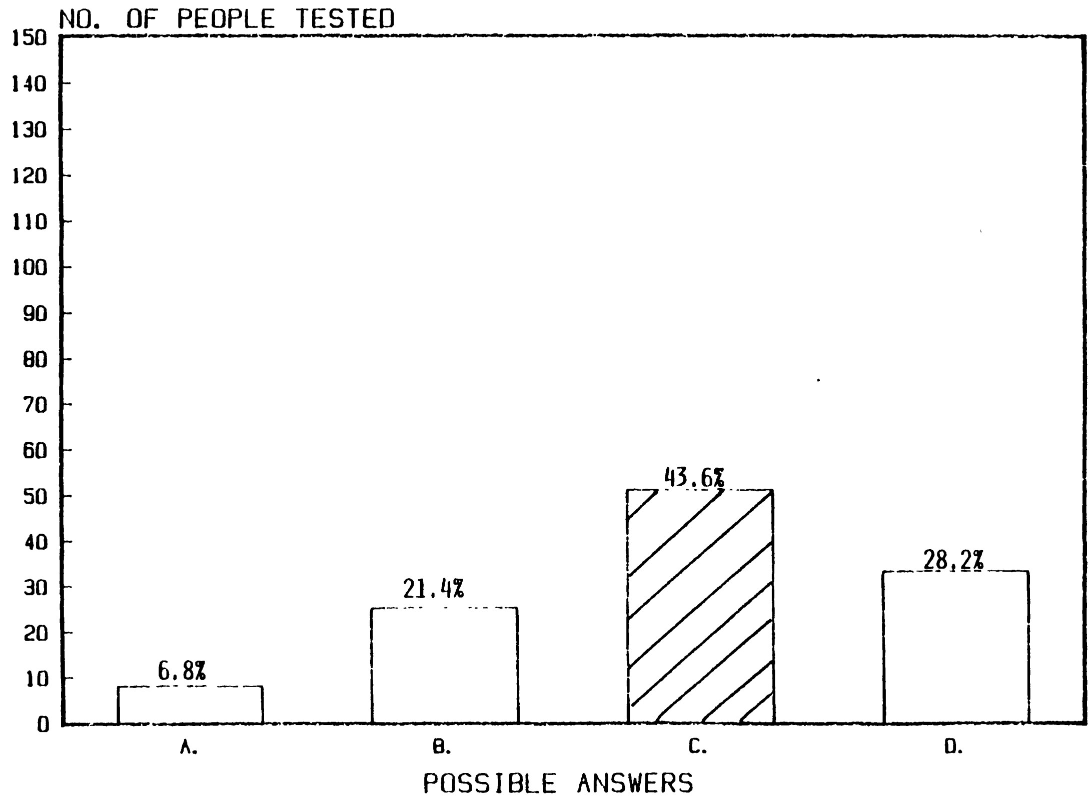
(A) a great deal of dissolved solids and is rated as soft

(B) a great deal of dissolved solids and is rated as very hard

(C) some dissolved solids and is rated as moderately hard to very hard

(D) very little dissolved solids and is rated as extremely soft

QUESTION FIFTEEN



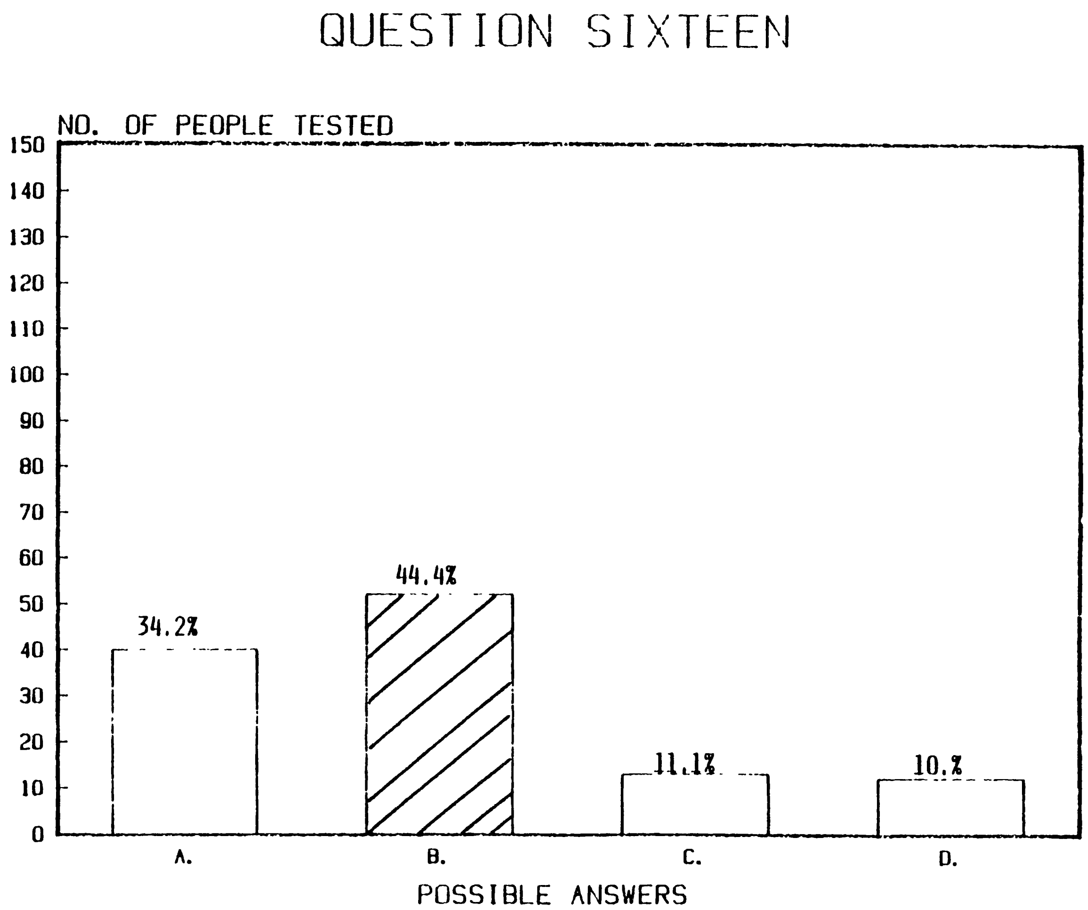
No.15. The process by which water is distributed around the world is:

(A) hydrophobic cycle

(B) transpiration system

(C) hydrologic cycle

(D) river systems



No.16. When was Oklahoma's last drought?

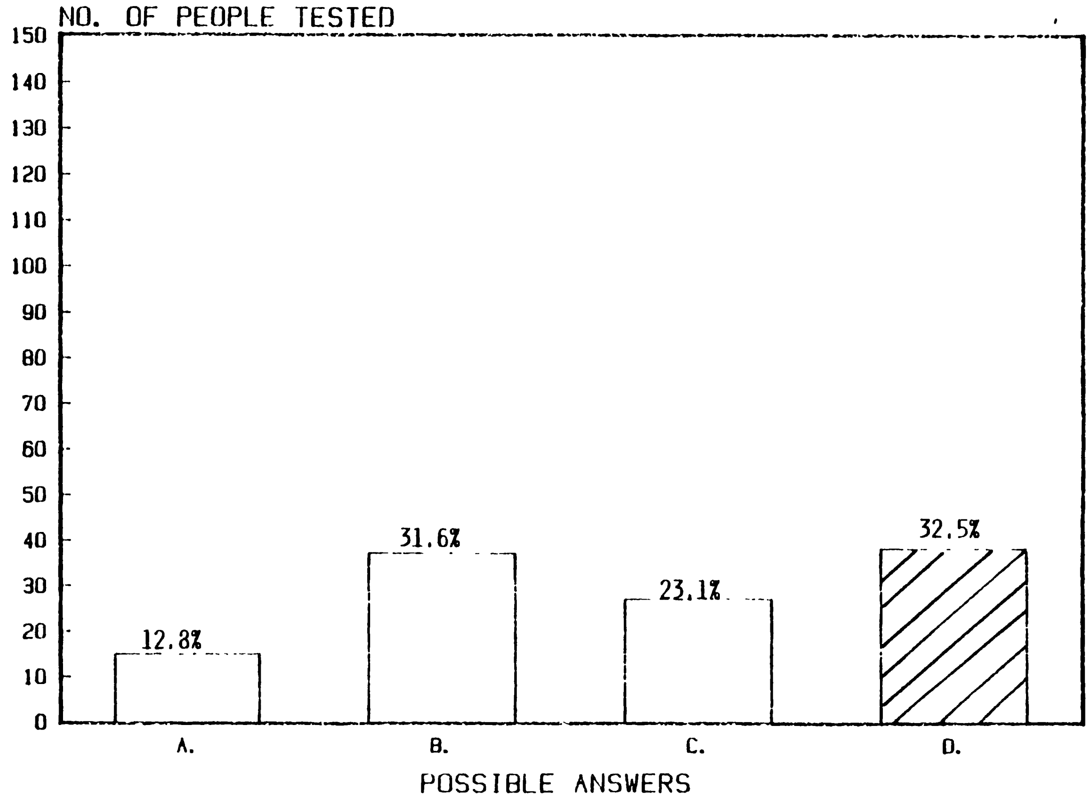
(A) 1930

(B) 1979

(C) 1950

(D) 1969

QUESTION SEVENTEEN



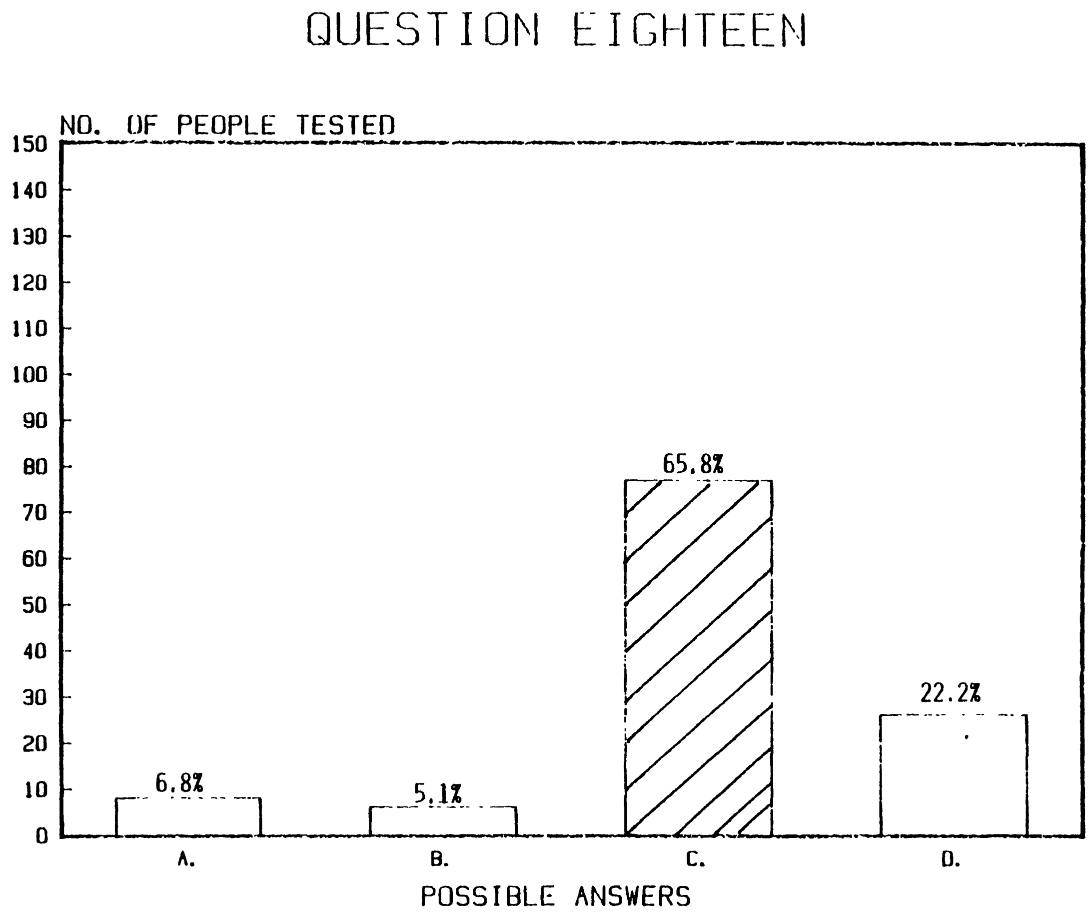
No.17. If you had to drink processed sewer water, which process would be best?

(A) secondary

(B) floculation

(C) primary

(D) tertiary



No.18. What is the Ogallala and the Roubidoux?

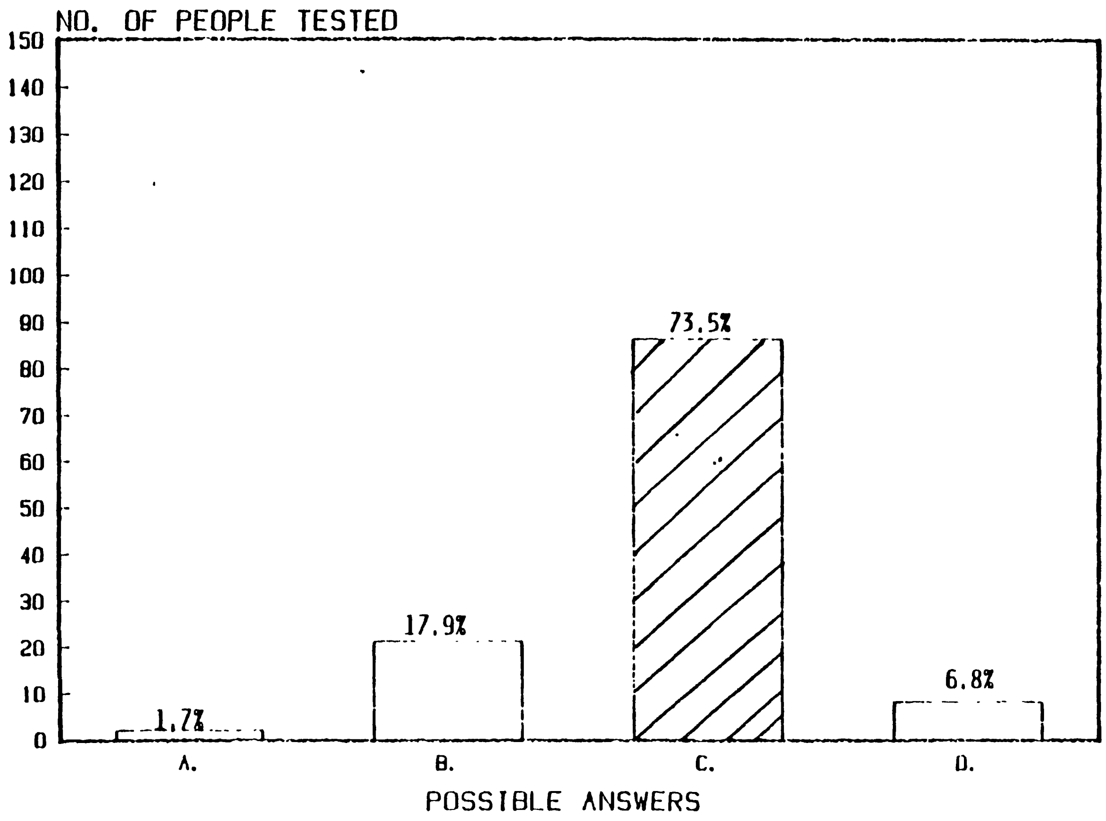
(A) Oklahoma mountains

(B) Oklahoma indian tribes

(C) Oklahoma aquifers

(D) Oklahoma rivers

QUESTION NINETEEN



No.19. How many hydrogen and oxygen atoms make up water?

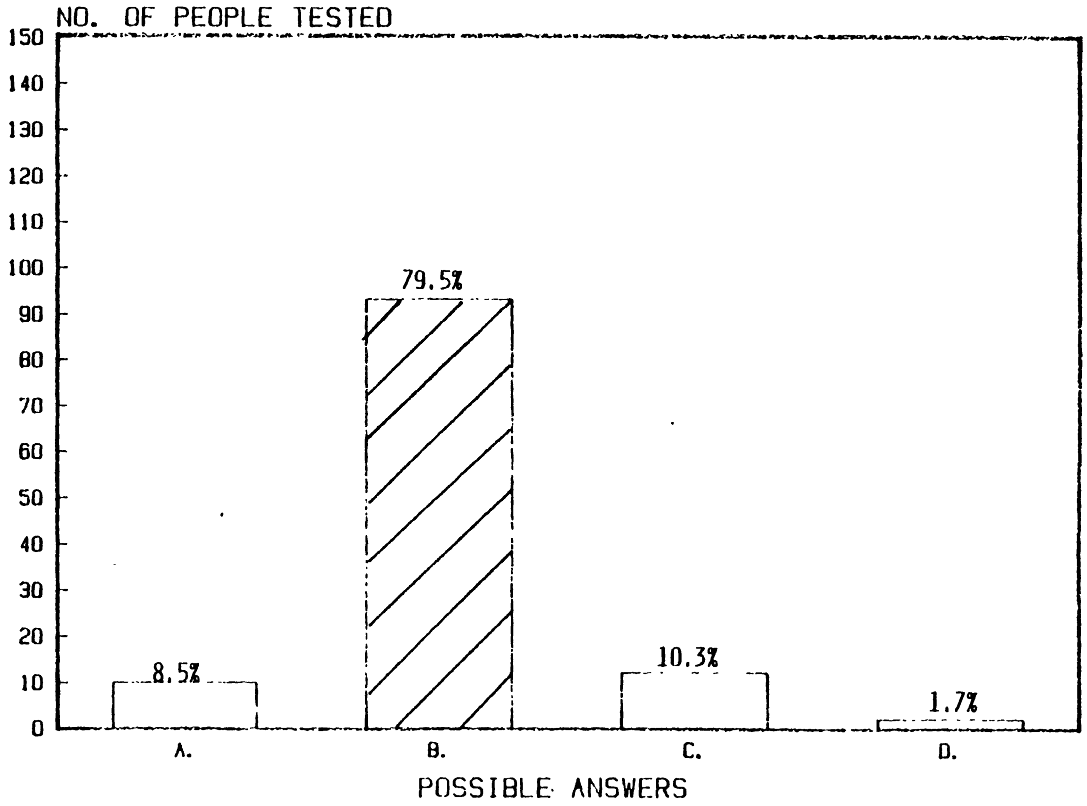
(A) Three hydrogens and two oxygens

(B) Two oxygens and one hydrogen

(C) One oxygen and two hydrogens

(D) Two hydrogens and three oxygens

QUESTION TWENTY



No.20. A water shed is:

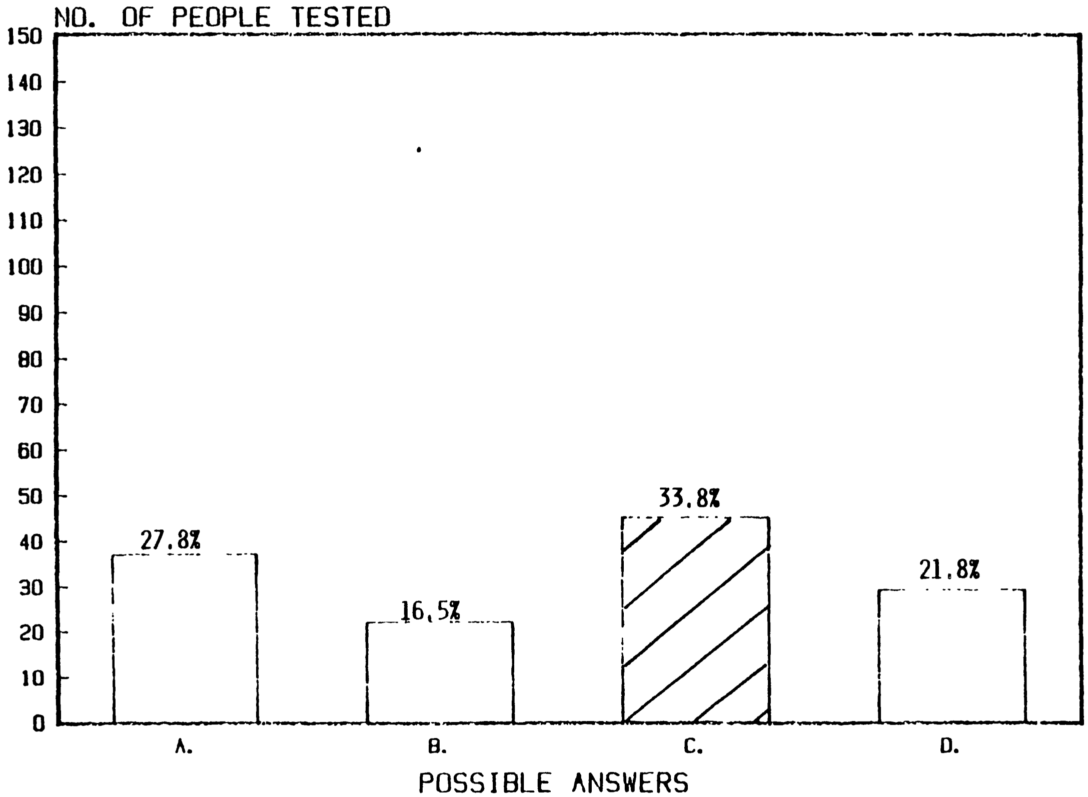
(A) A shed where water is kept and cooled

(B) The area drained by a stream

(C) A canopy of trees that over-hang and shade a stream

(D) An outdoor toilet

QUESTION TWENTY-ONE



No. 21.
Nintey-seven percent of the worlds water is in its' oceans. Of the remaining three percent where is the majority to be found?

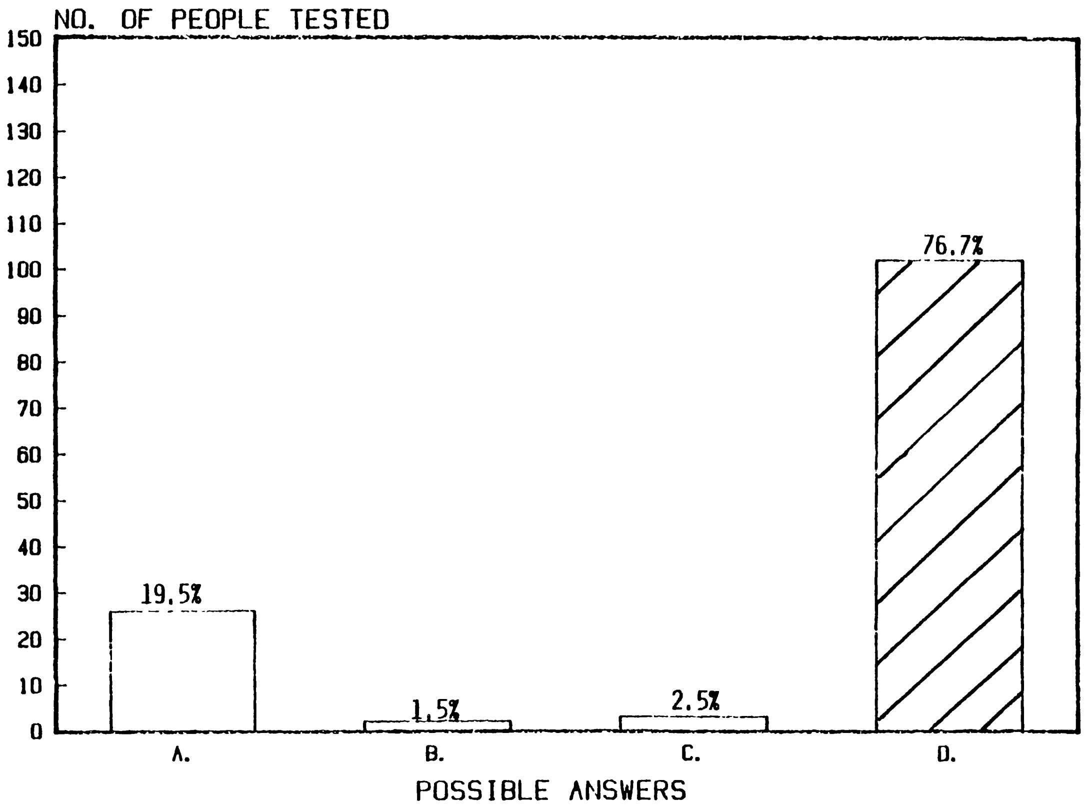
(A) Streams and Rivers

(B) Lakes

(C) Glaciers

(D) Atmosphere

QUESTION TWENTY-TWO



No. 22. Where is water created?

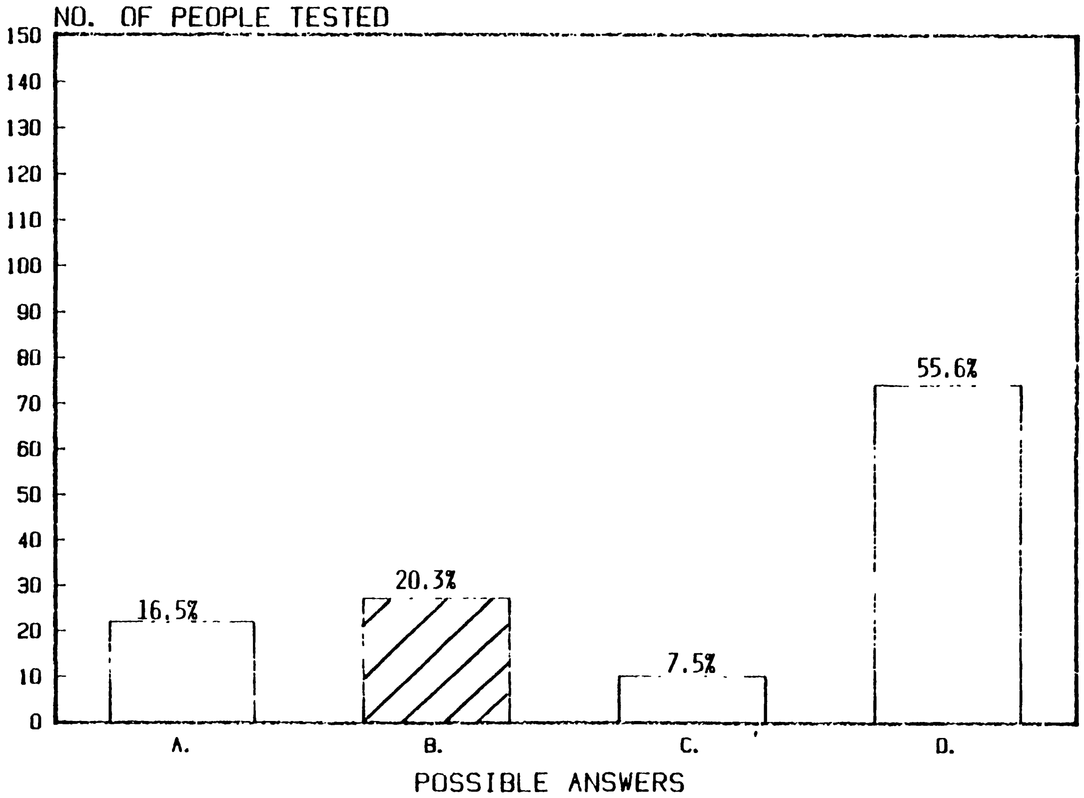
(A) In clouds before a storm

(B) By rainforests

(C) By tidal action of the oceans

(D) Not at all; it is recycled

QUESTION TWENTY-THREE



No. 23. What civilization vanished from Oklahoma due to a drought?

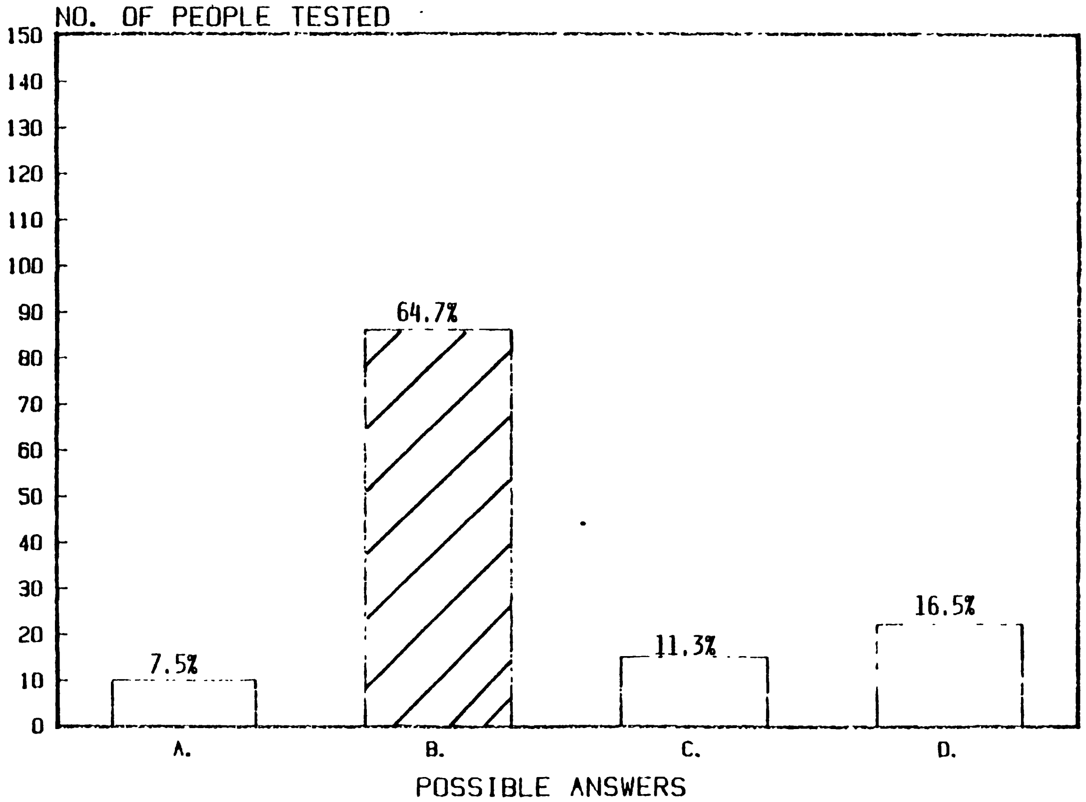
(A) Washita River culture

(B) Spiro Mound culture

(C) Okie culture

(D) None have ever vanished due to drought.

QUESTION TWENTY-FOUR



No. 24. A major aquifer in Oklahoma is the

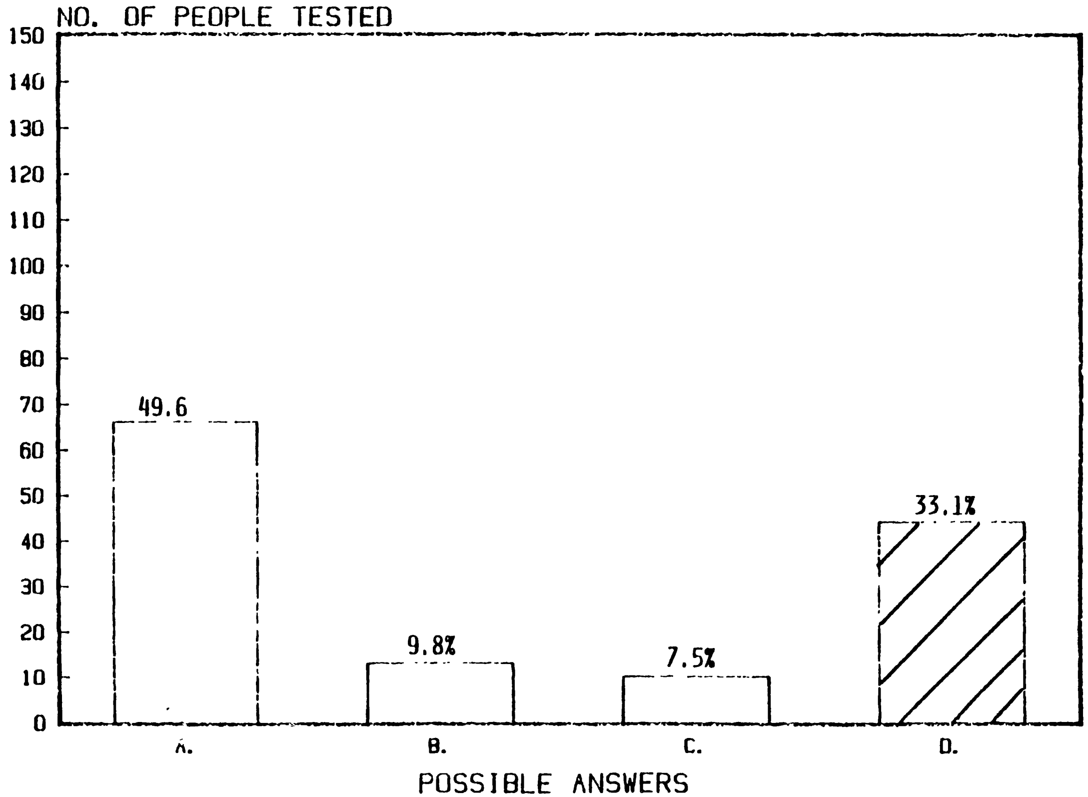
(A) Perrniam

(B) Ogallala

(C) Nubian

(D) Hennesey Shale

QUESTION TWENTY-FIVE



No. 25. Oklahoma water users can be divided into munipal, energy, industrial and agriculture. Which of the following uses the most water?

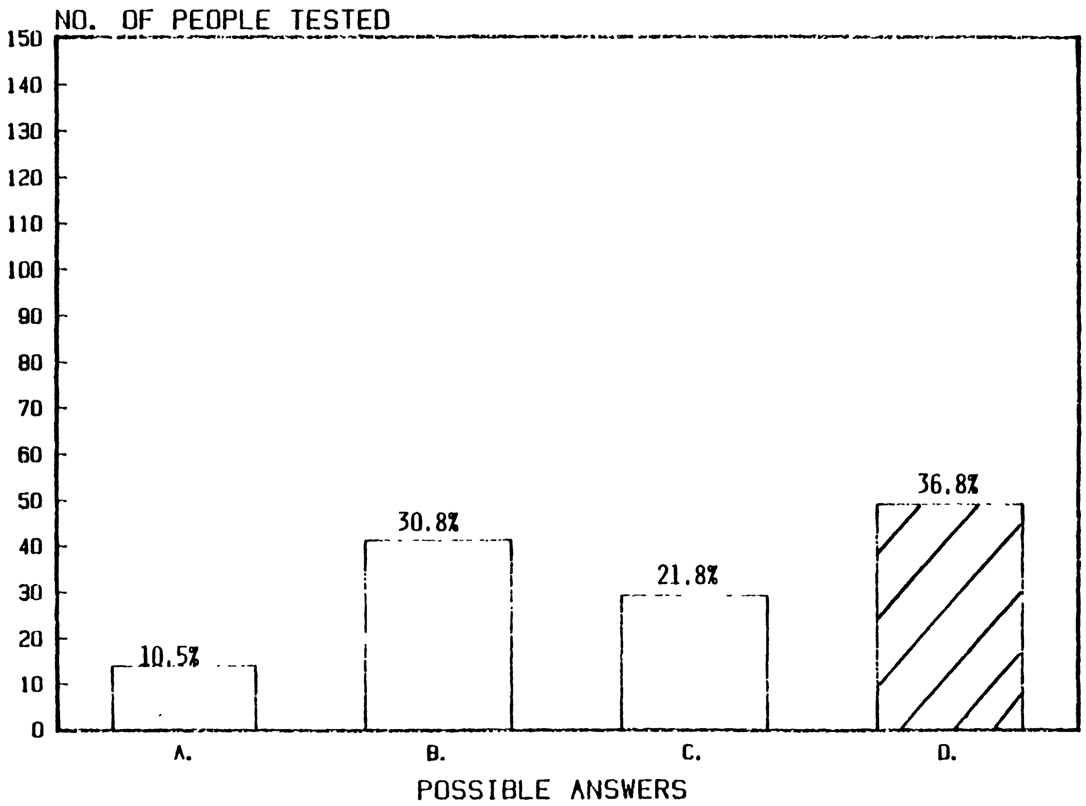
(A) Municipal/Industrial

(B) Industrial

(C) Energy

(D) Agriculture

QUESTION TWENTY-SIX



No. 26. Which of the following sewage treatment procedures returns the least polluted water back into the water system?

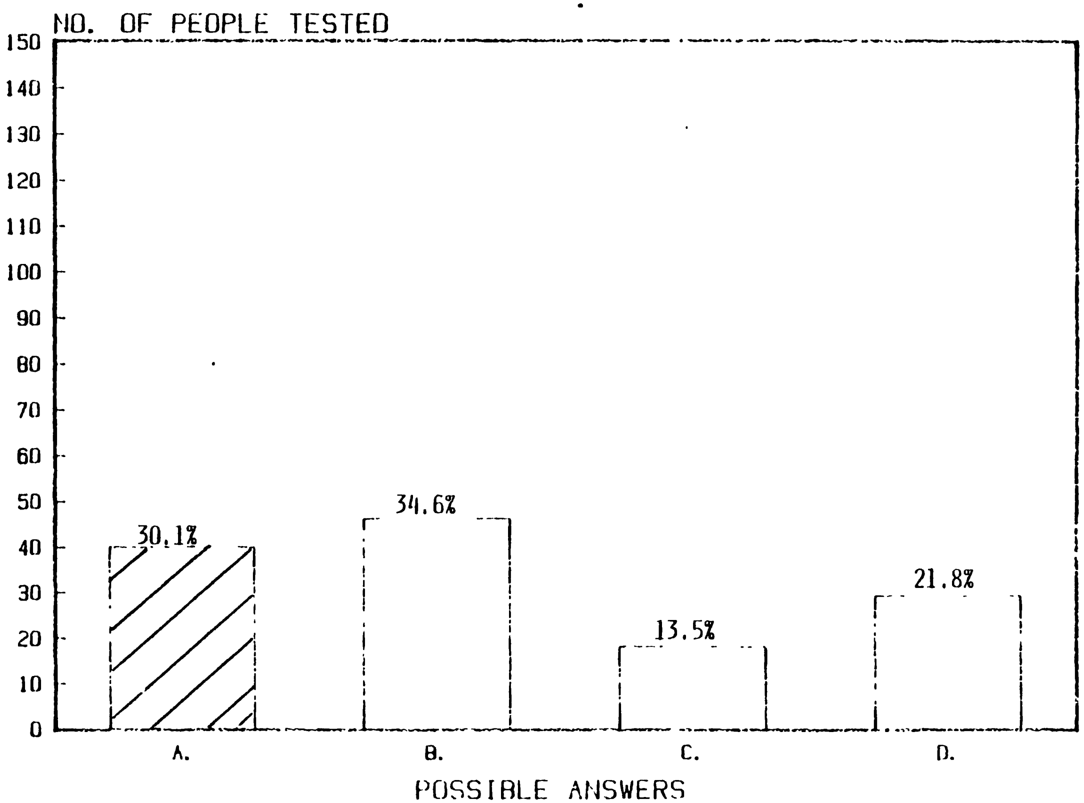
(A) Secondary

(B) Floculation

(C) Primary

(D) Tertiary

QUESTION TWENTY-SEVEN



No. 27. Which of the following irrigation methods requires the least amount of water?

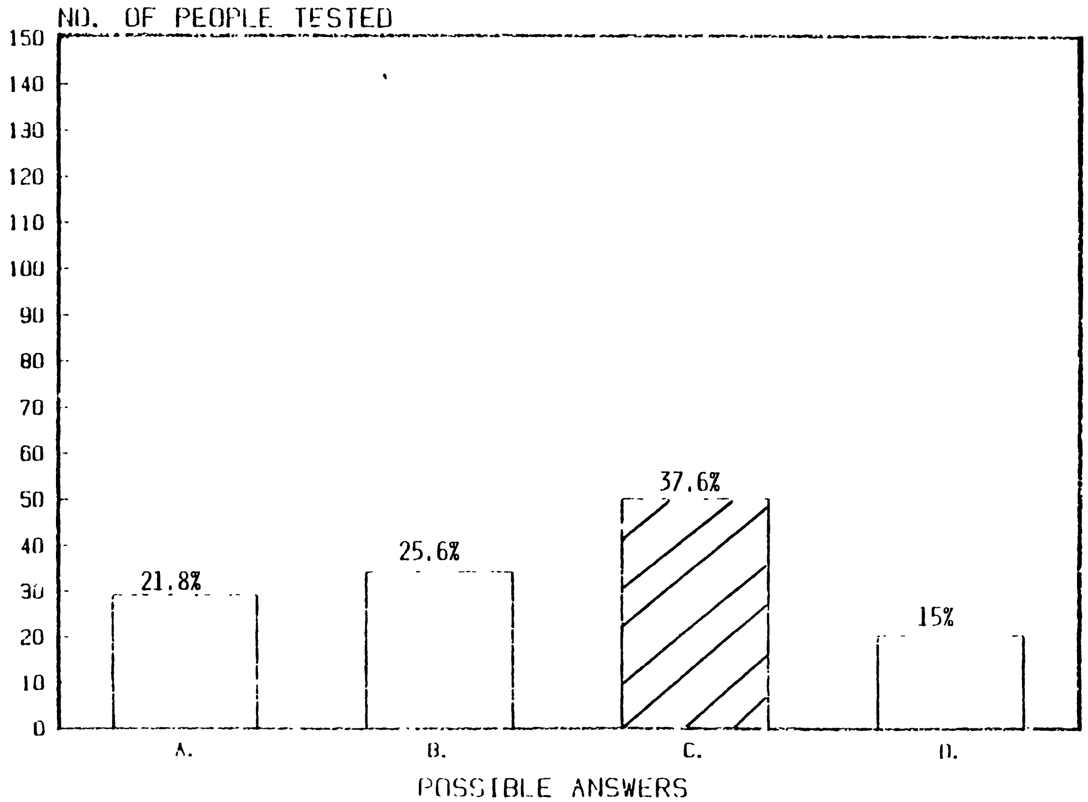
(A) Sprinkler method

(B) Percolation method

(C) Flood method

(D) Hydrologic

QUESTION TWENTY EIGHT



No. 28. The greatest water pollutant in Oklahoma is:

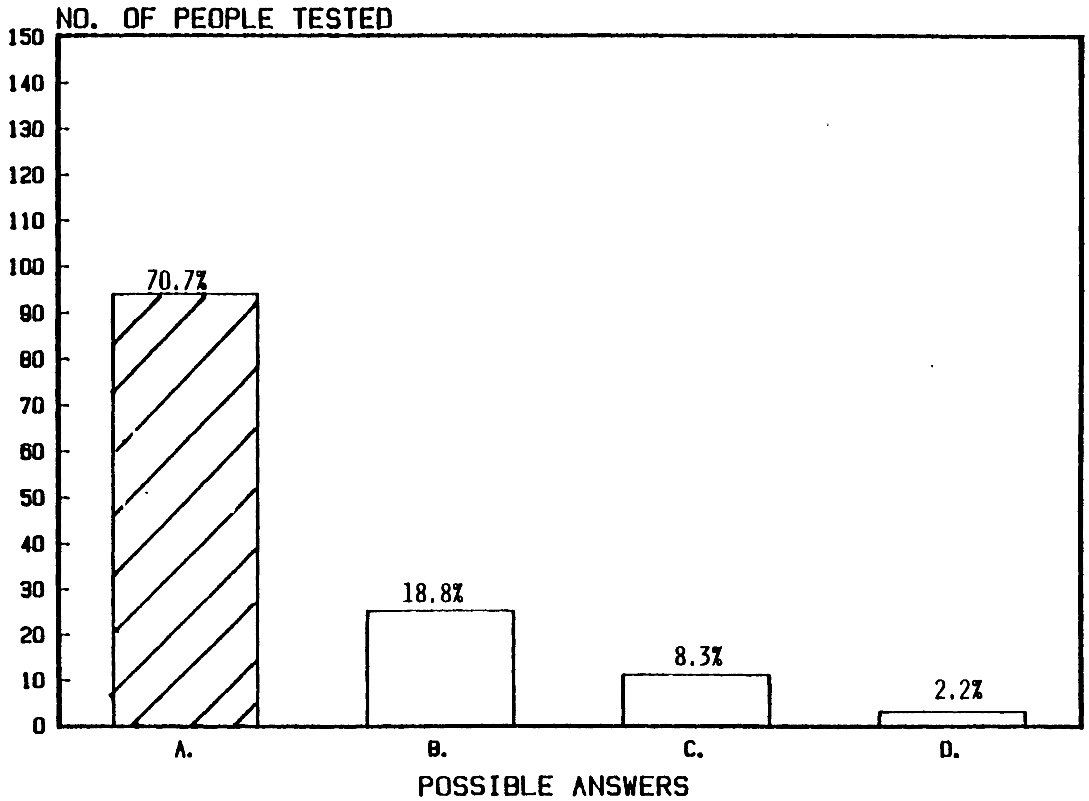
(A) Salt

(B) PCB's

(C) Silt

(D) DDT

QUESTION TWENTY-NINE



No. 29. What is transpiration?

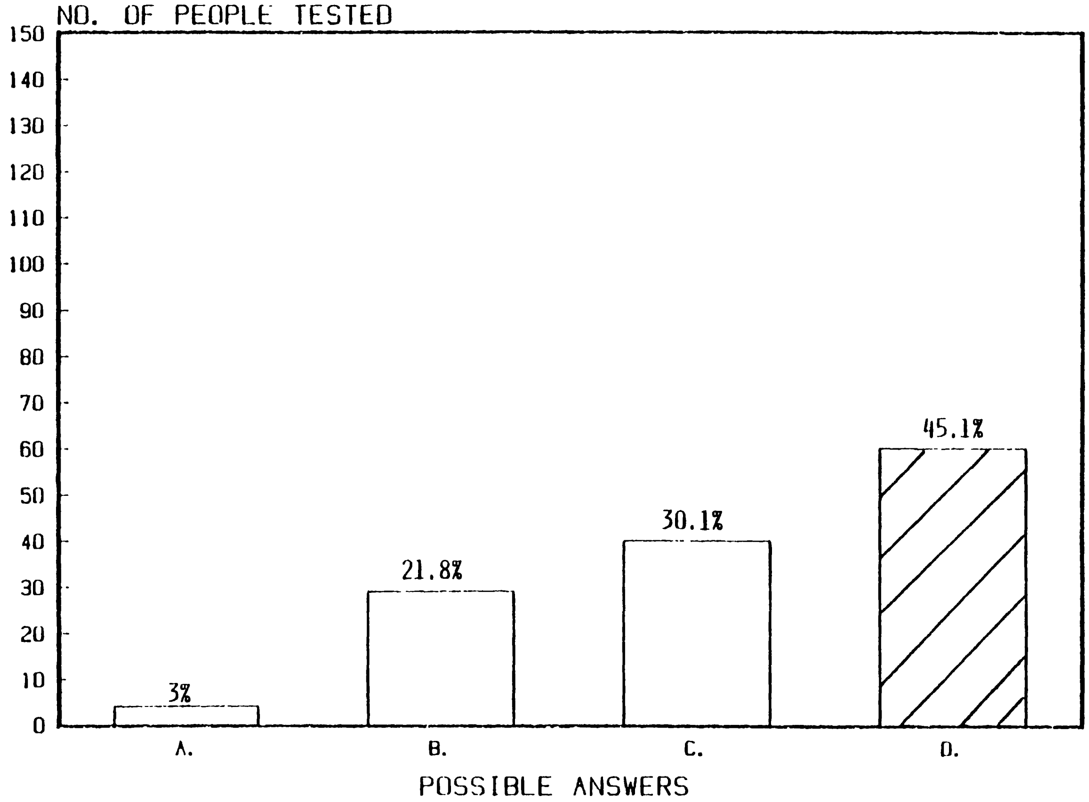
(A) Evaporation of water from the leaves of plants

(B) A graphical representation of flow, level, and other properties of water

(C) The addition of water to an aquifer

(D) Statistical study of populations

QUESTION THIRTY



No. 30. Oklahoma's rivers feed into what two major rivers?

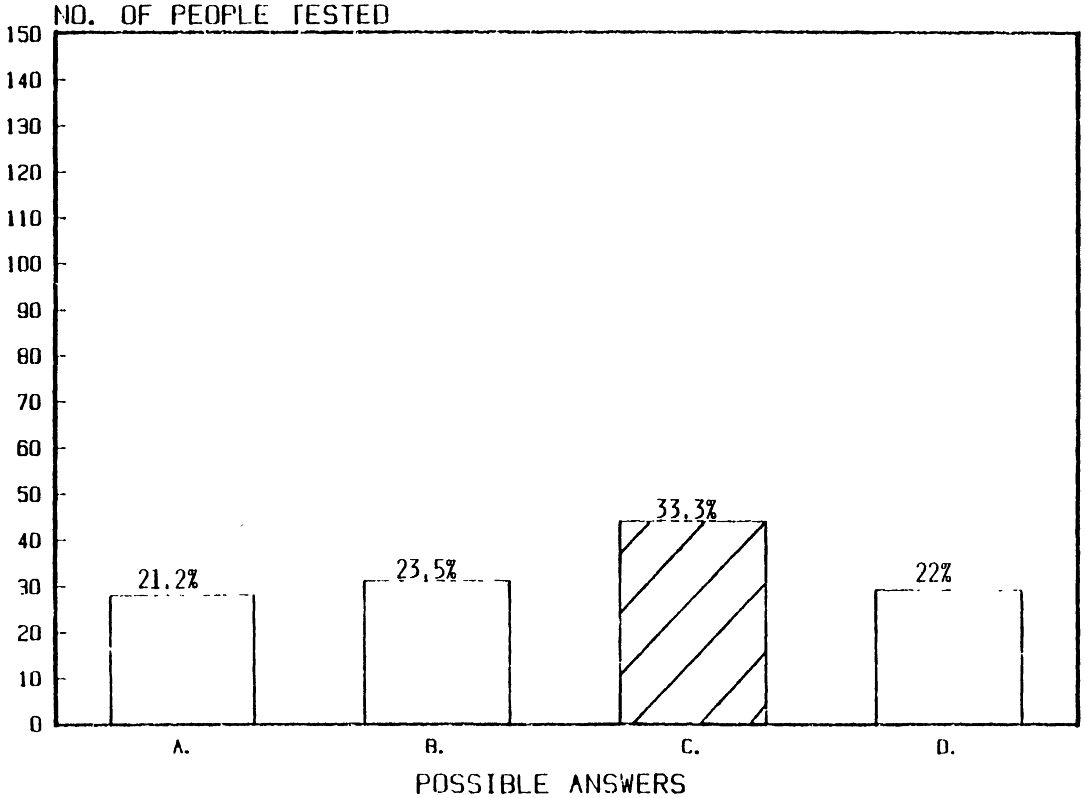
(A) Canadian and Verdigris

(B) Red and Mississippi

(C) Arkansas and Canadian

(D) Red and Arkansas

QUESTION THIRTY-ONE



No. 31. Which of the following irrigation methods returns the most water back into the surface reserve?

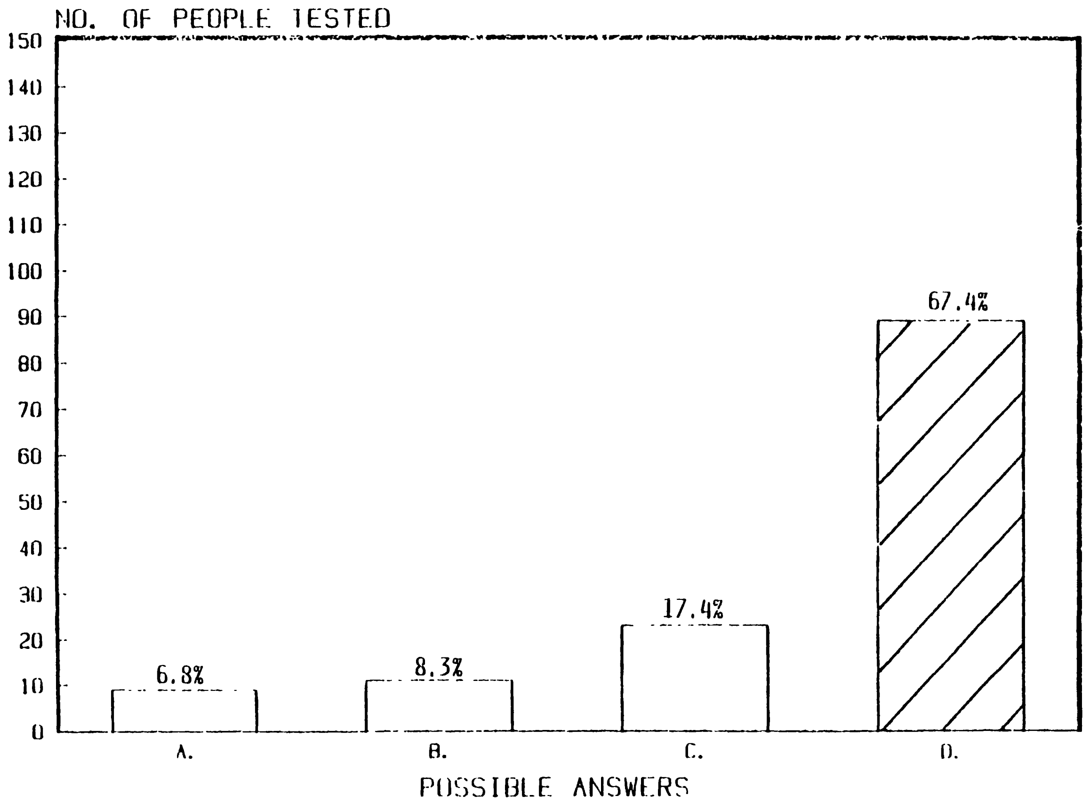
(A) Sprinkler

(B) Percolation

(C) Flood

(D) Hydrologic

QUESTION THIRTY-TWO



No. 32. Most of the earth's water is stored in

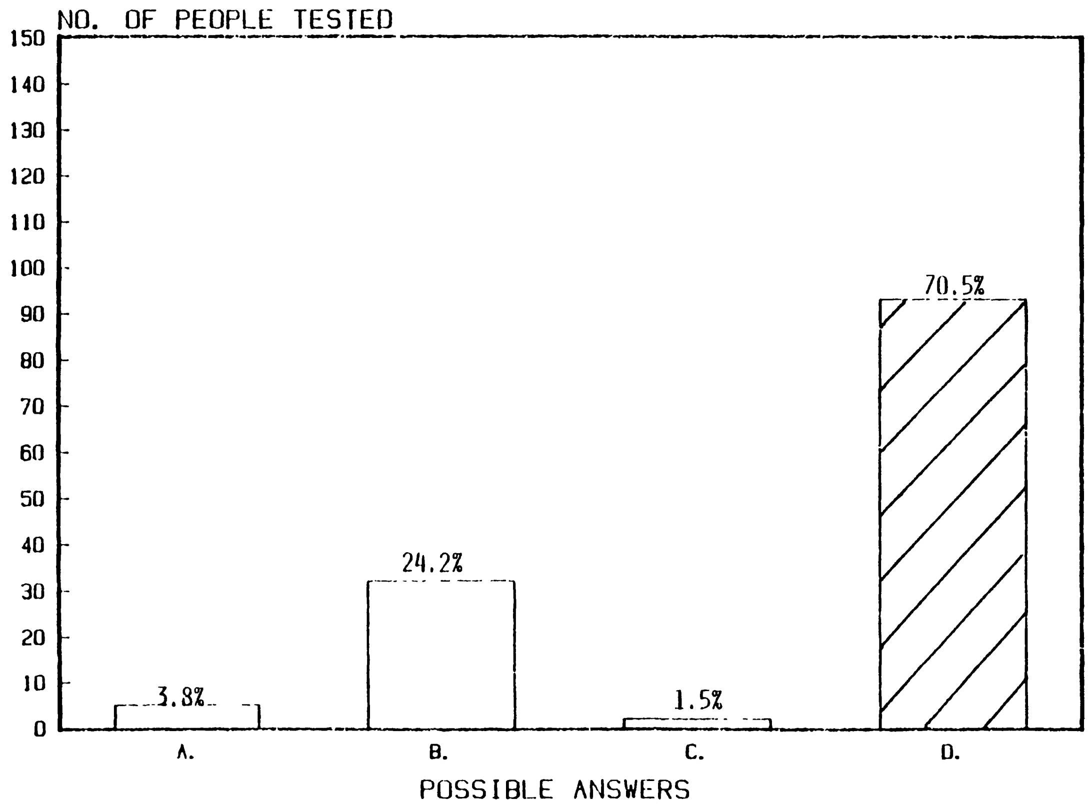
(A) Precipitation and clouds

(B) Rivers and lakes

(C) Ground water and lakes

(D) Oceans and snowpack

QUESTION THIRTY-THREE



No. 33. What is evapotranspiration?

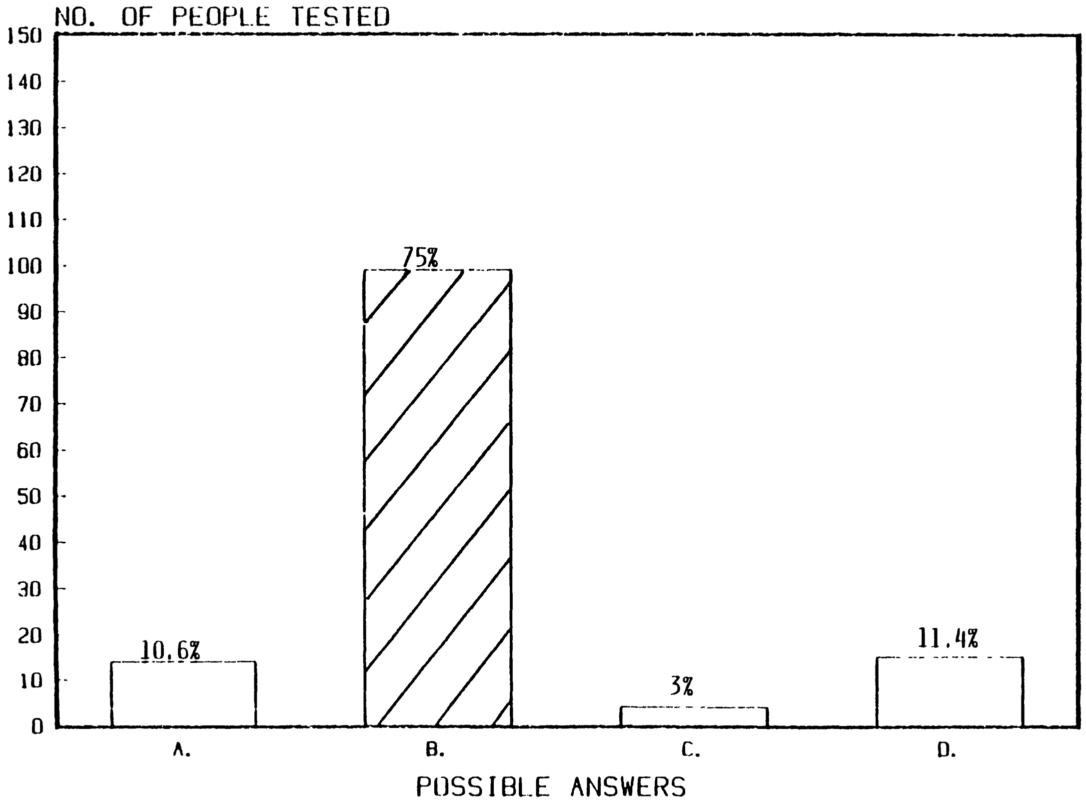
(A) Precipitation from clouds

(B) Evaporation of water from the leaves of plants

(C) Statistical study of water in aquifers

(D) Loss of water from a land area through transpiration of plants and evaporation from the soil

QUESTION THIRTY-FOUR



No. 34. Oklahoma's early expansion and development was based primarily on the availibility of

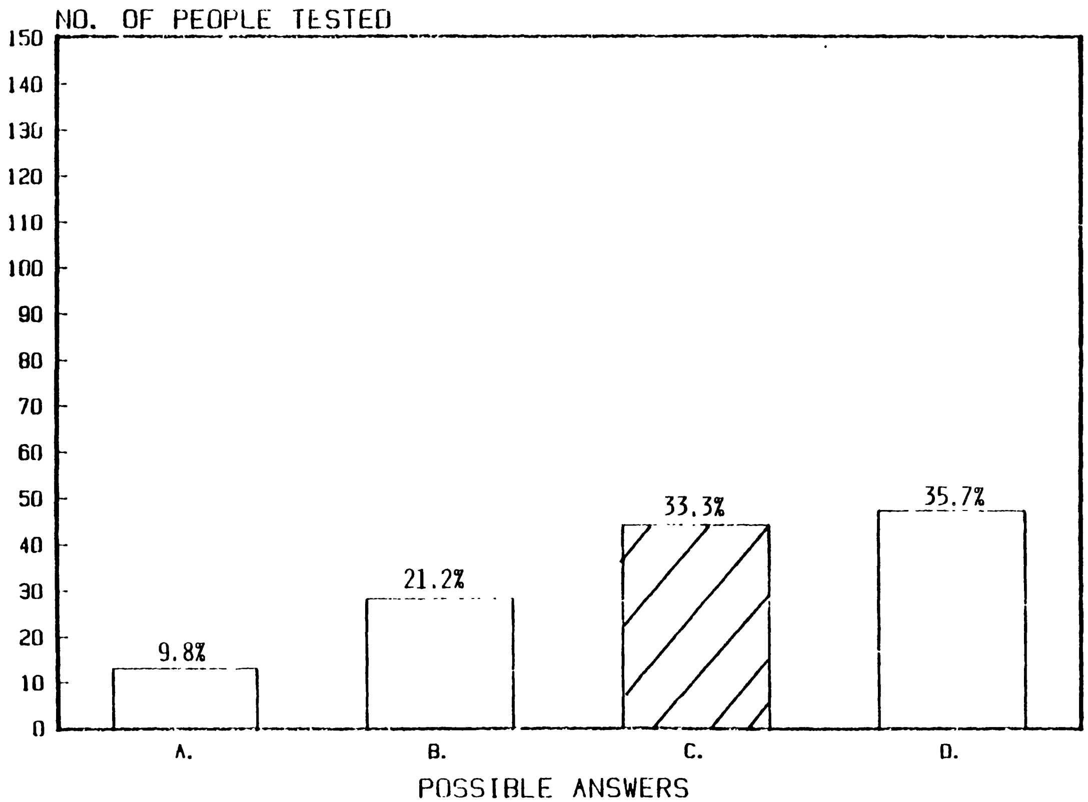
(A) Food

(B) Water

(C) Shelter

(D) Entertainment

QUESTION THIRTY-FIVE



No. 35. In Oklahoma, water used for irrigation comes from underground wells and surface reservoirs. The ratio of use is

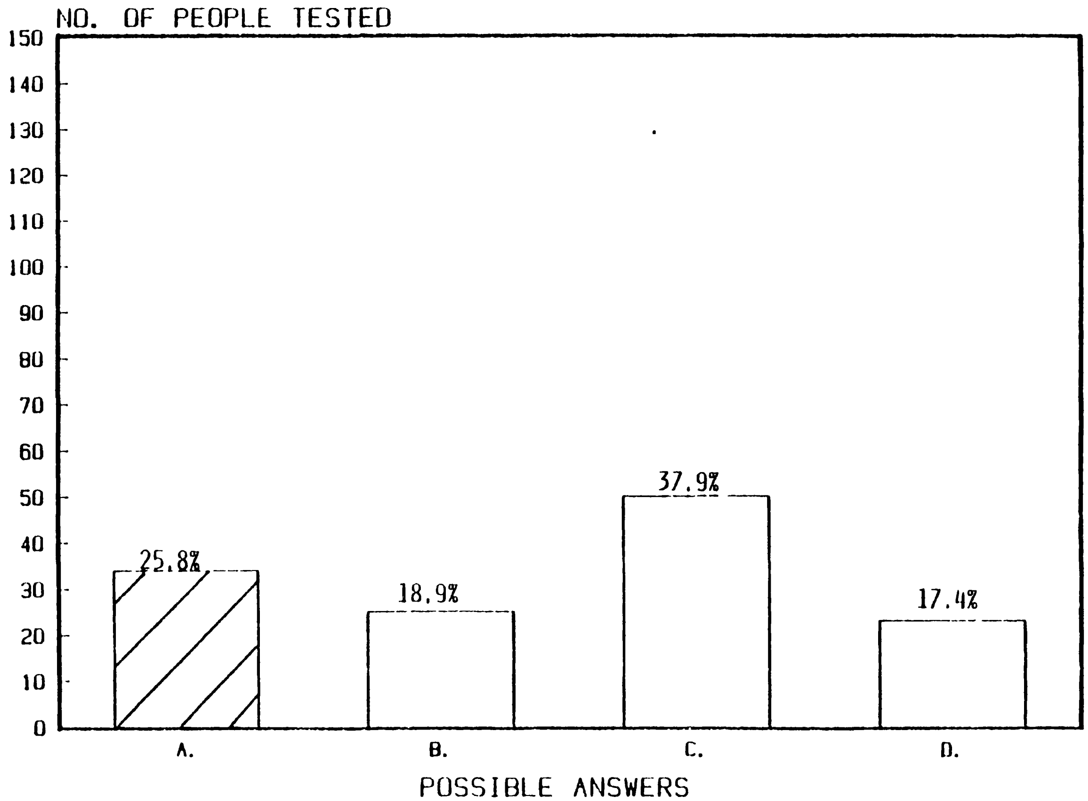
(A) Surface water is used ten times as much as ground water

(B) Surface water is used five times as much as ground water

(C) Ground water is used ten times as much as surface water

(D) Ground water is used five times as much as surface water

QUESTION THIRTY-SIX



No. 36. How many inches of water per year evaporates from Oklahoma's lakes?

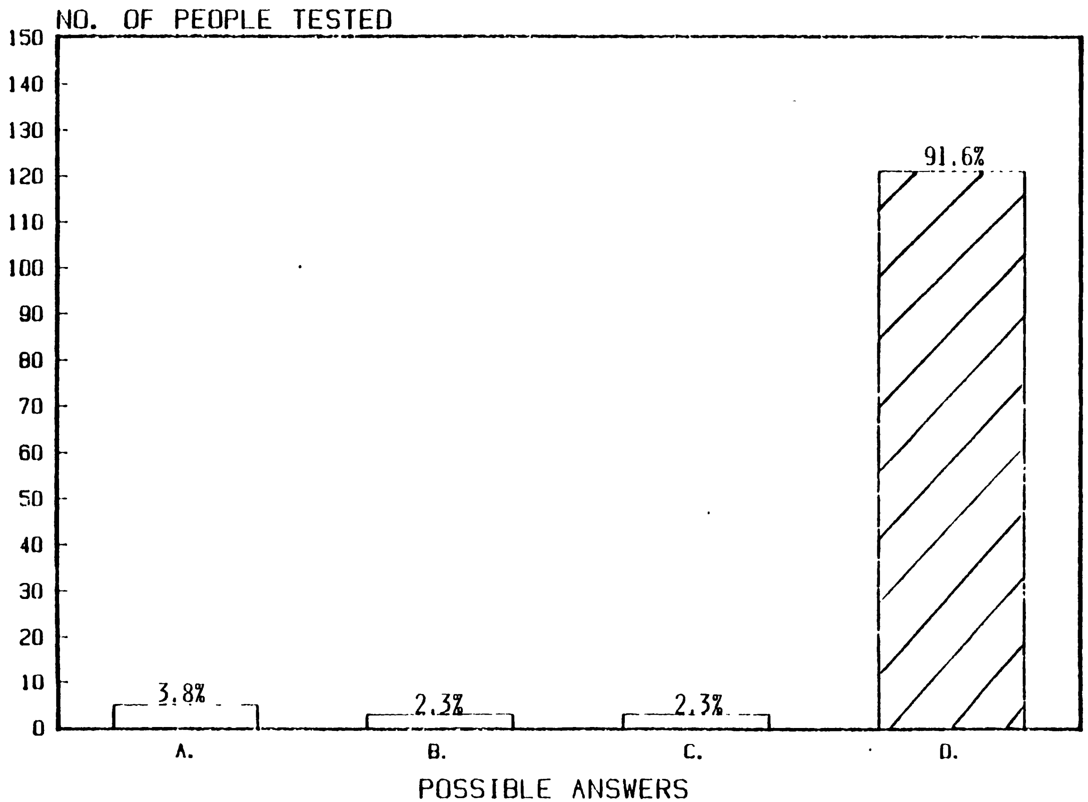
(A) 60-70 inches

(B) 12-18 inches

(C) 30-40 inches

(D) 100-120 inches

QUESTION THIRTY-SEVEN



No. 37. Nature distributes rainfall ___________.

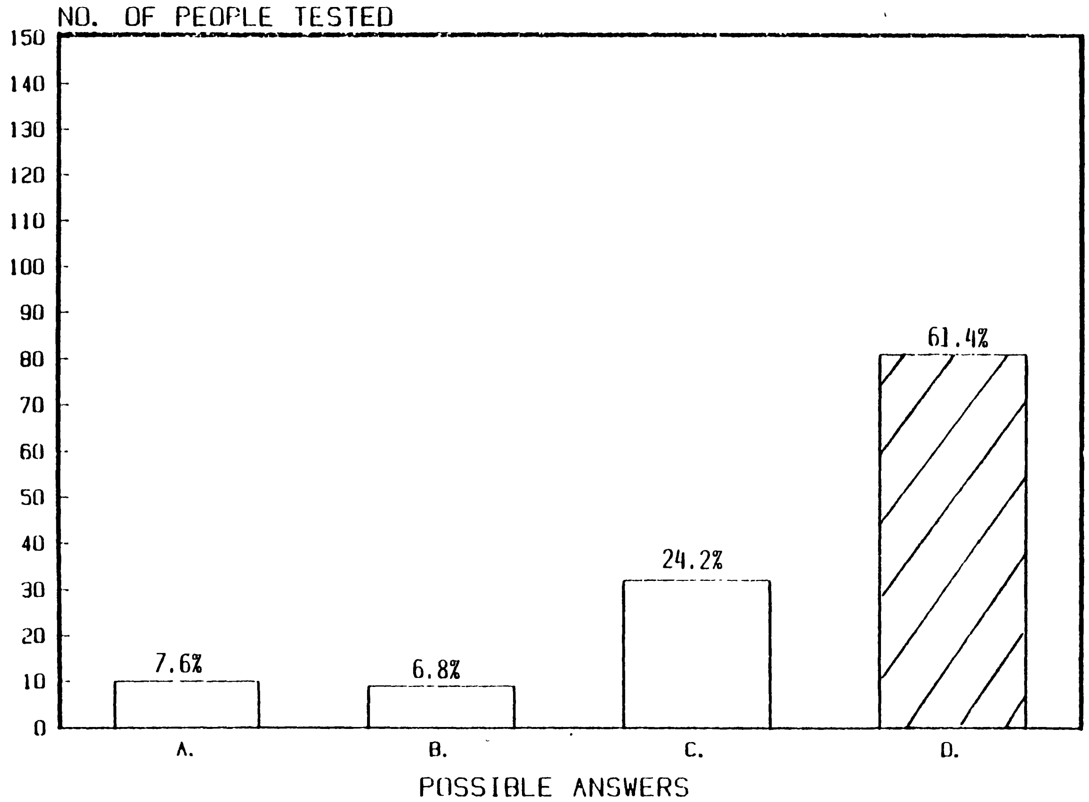
(A) evenly around the earth

(B) mostly in the U.S. and Canada

(C) where it is most needed

(D) unevenly

QUESTION THIRTY-EIGHT



No. 38. An area with a surplus of precipitation would be likely to have all of the following except __________.

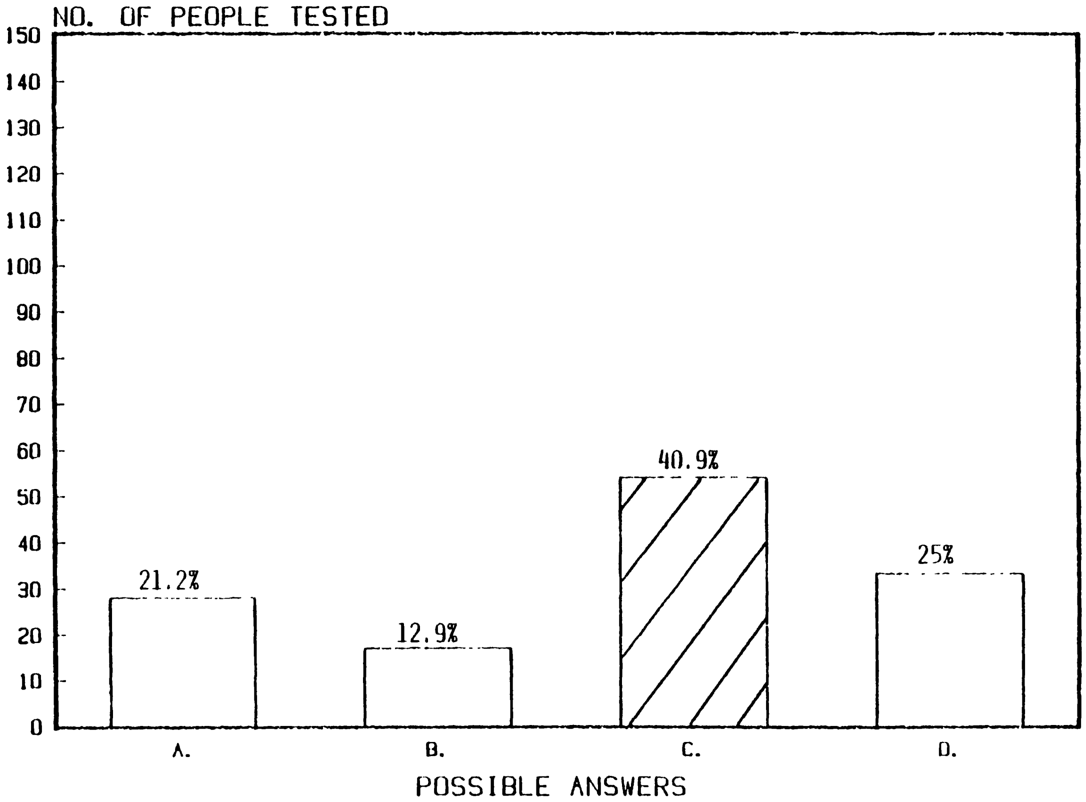
(A) a flowing stream

(B) natural lakes

(C) high humidity

(D) high rate of evaporation

QUESTION THIRTY-NINE



No. 39. The aquifers in the U.S. hold several times the amount of water as ________.

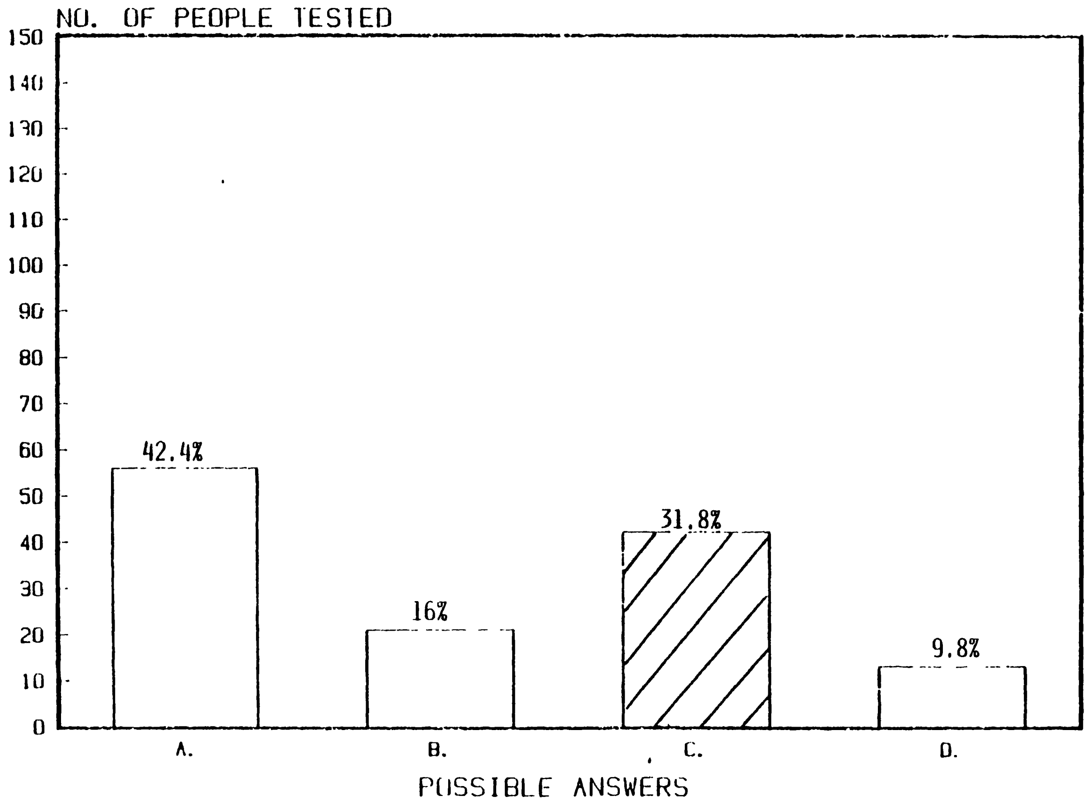
(A) all of our reservoirs

(B) all of our rivers

(C) all of our lakes and reservoirs combined

(D) all of our municipal water plants

QUESTION FORTY



No. 40. A lake in _____ part of Oklahoma would probably have less surface evaporation than a lake of comparable size in any other part of Oklahoma.

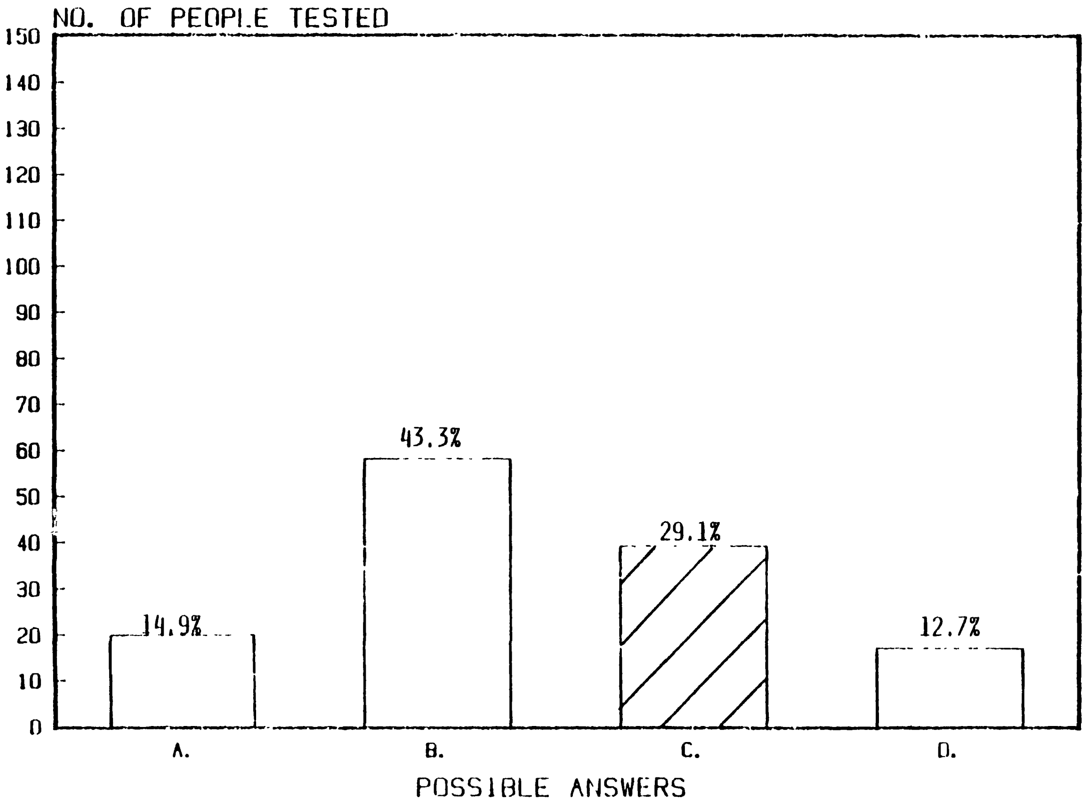
(A) Northeastern

(B) Northwestern

(C) Southeastern

(D) Southwestern

QUESTION FORTY-ONE



No. 41. A lake in the _____ part of Oklahoma would probably have more surface evaporation than a lake of comparable size in any other part of Oklahoma.

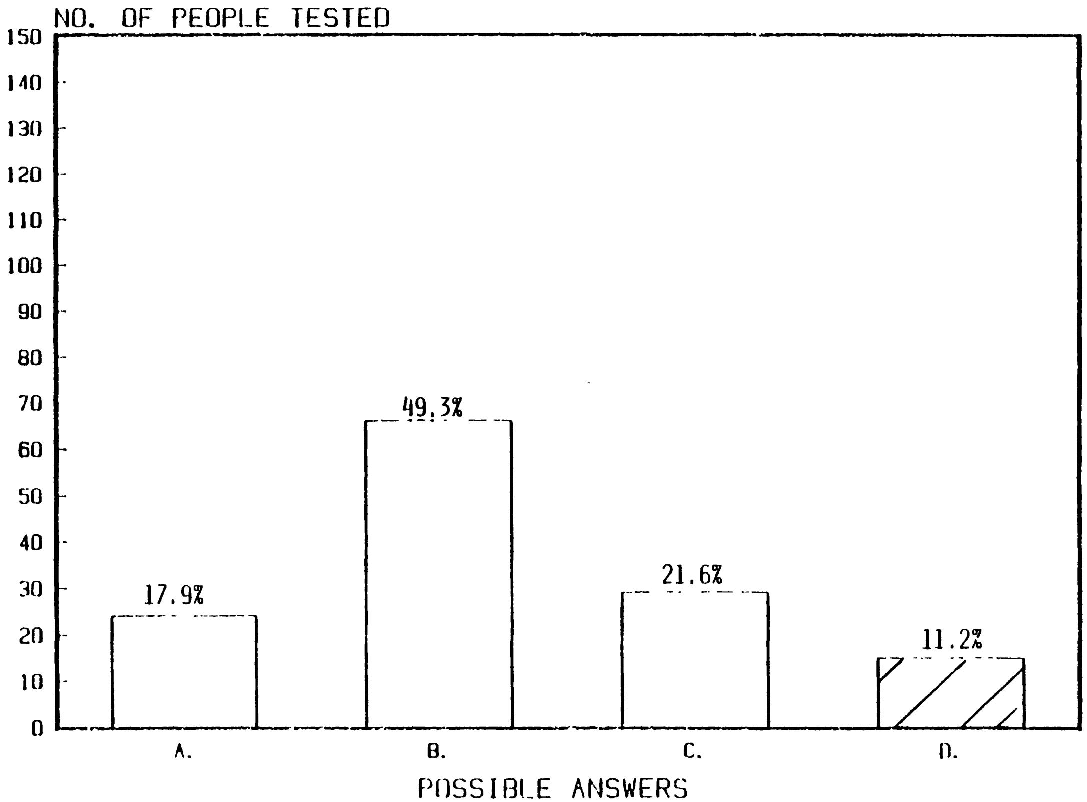
(A) Northeastern

(B) Southwestern

(C) Northwestern

(D) Southeastern

QUESTION FORTY-TWO



No. 42. The approximate difference in average annual precipitation between northwest Oklahoma and southeast Oklahoma is __________.

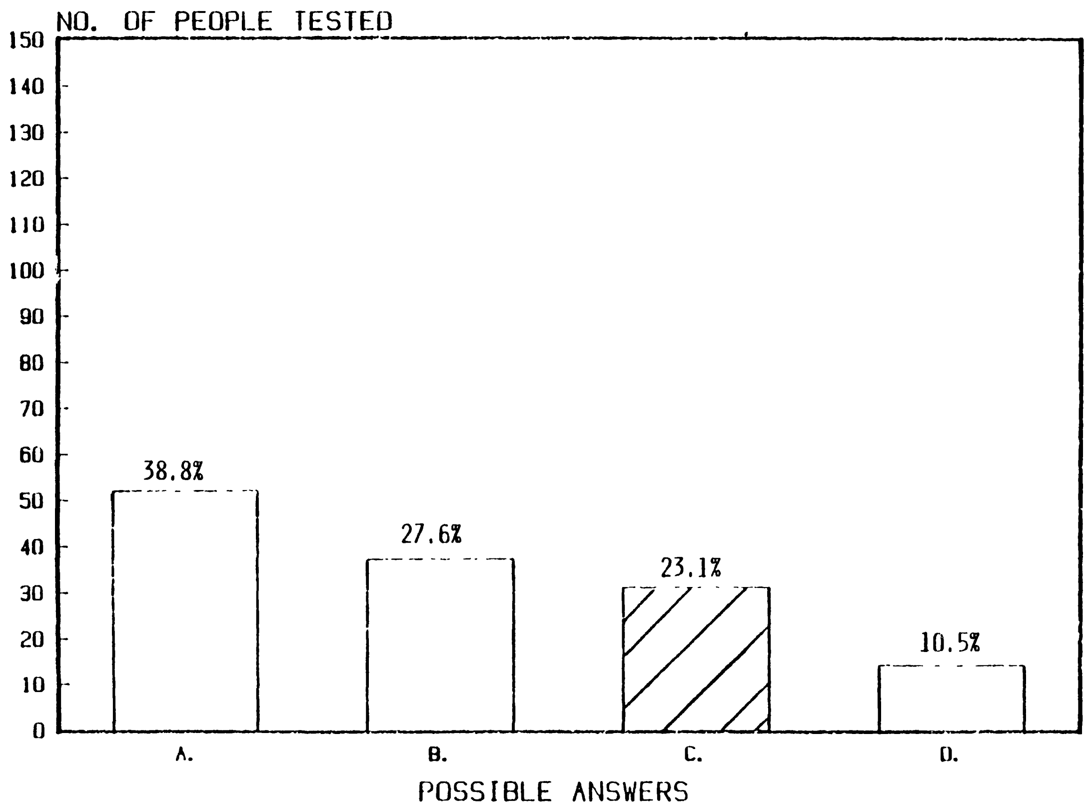
(A) six inches

(B) fifteen inches

(C) twenty-four inches

(D) thirty-eight inches

QUESTION FORTY-THREE



No. 43. ______ uses the largest quantity of water in and around the home.

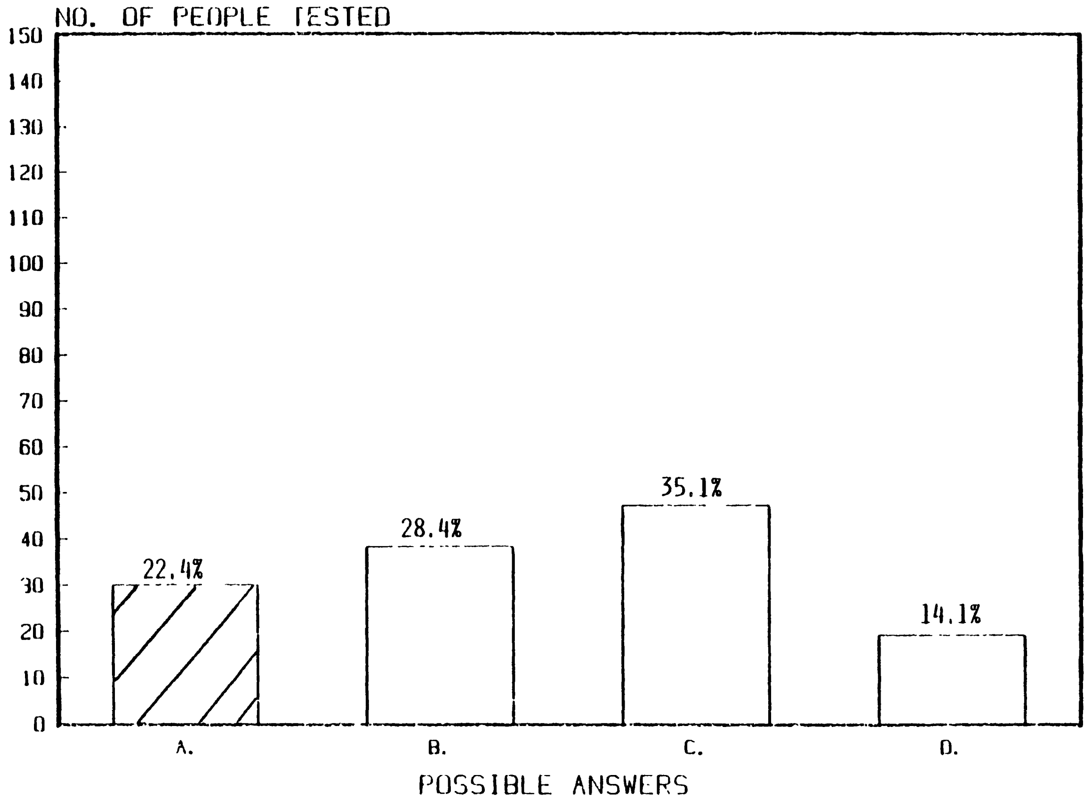
(A) toilet flushing

(B) bathing

(C) yard watering

(D) cleaning

QUESTION FORTY-FOUR



No. 44. It takes about ________ gallons of water to produce enough cotton to make one T-shirt.

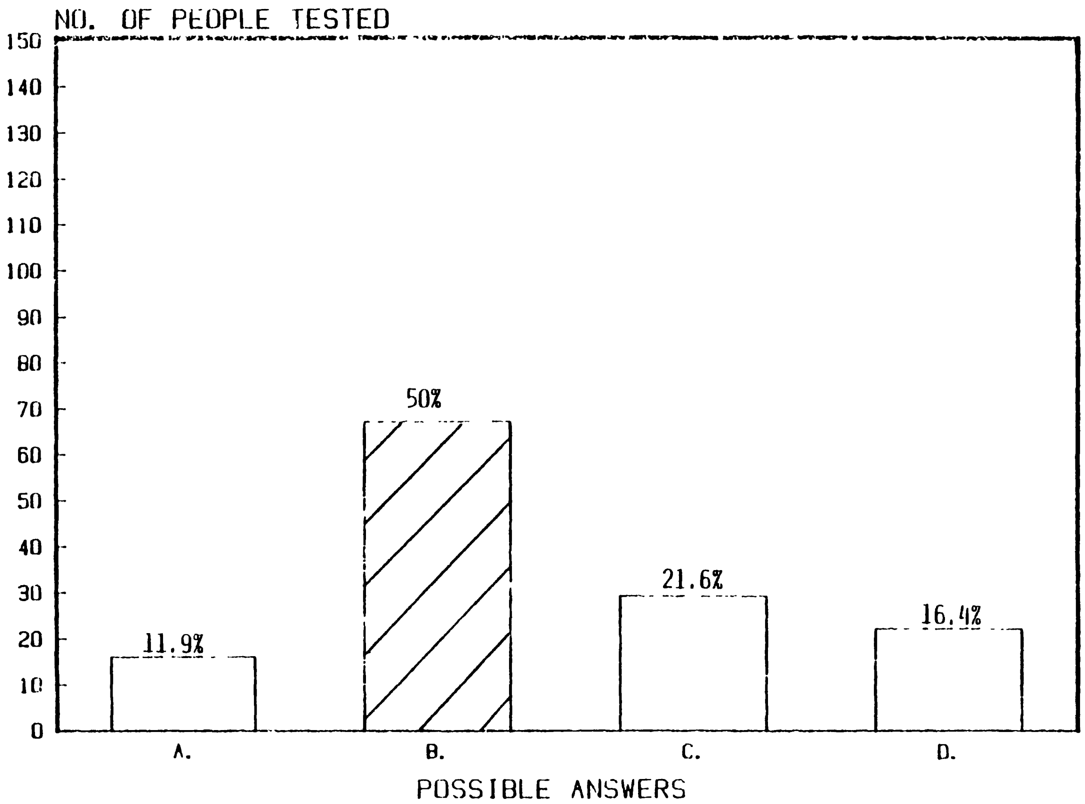
(A) 580 gallons

(B) 50 gallons

(C) 125 gallons

(D) 10 gallons

QUESTION FORTY-FIVE



No. 45. The water table is ______.

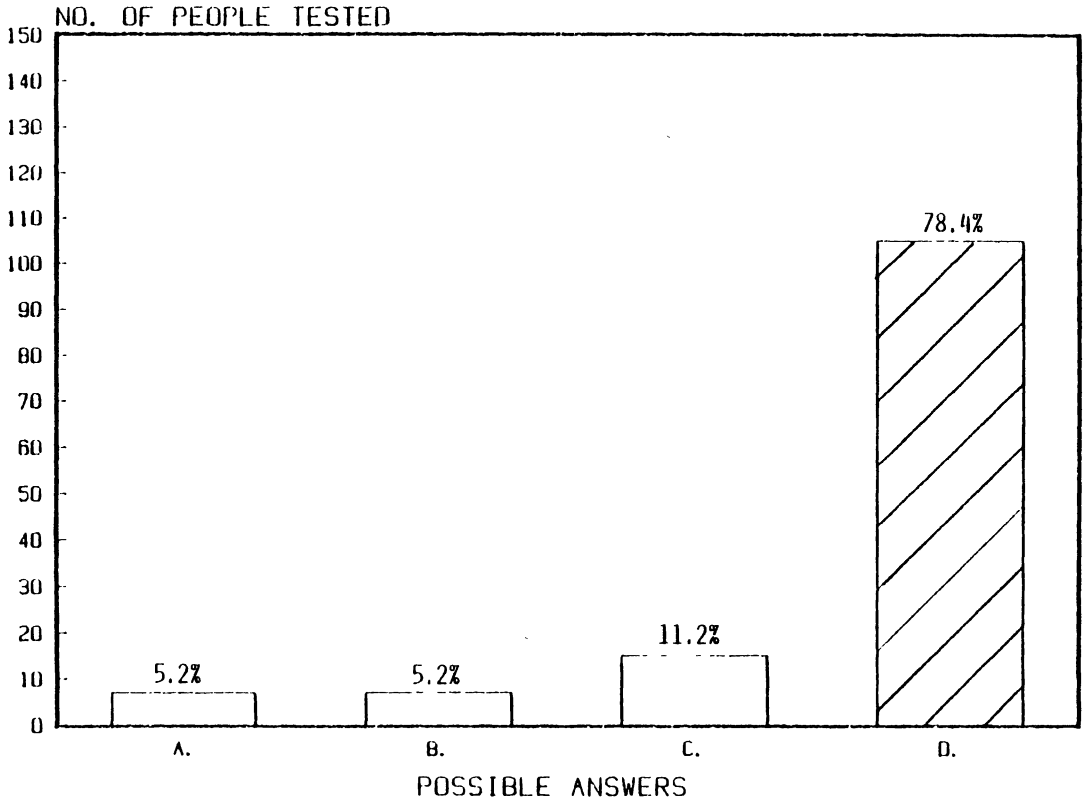
(A) an instrument used to measure well depth

(B) the point in the aquifer nearest the earth's surface saturated with water

(C) the careful and accurate record of well depths kept in each region

(D) a flat underground rock surface covered with water

QUESTION FORTY-SIX



No. 46. Water's chemical balance between alkalinity and acidity is referred to as its __________.

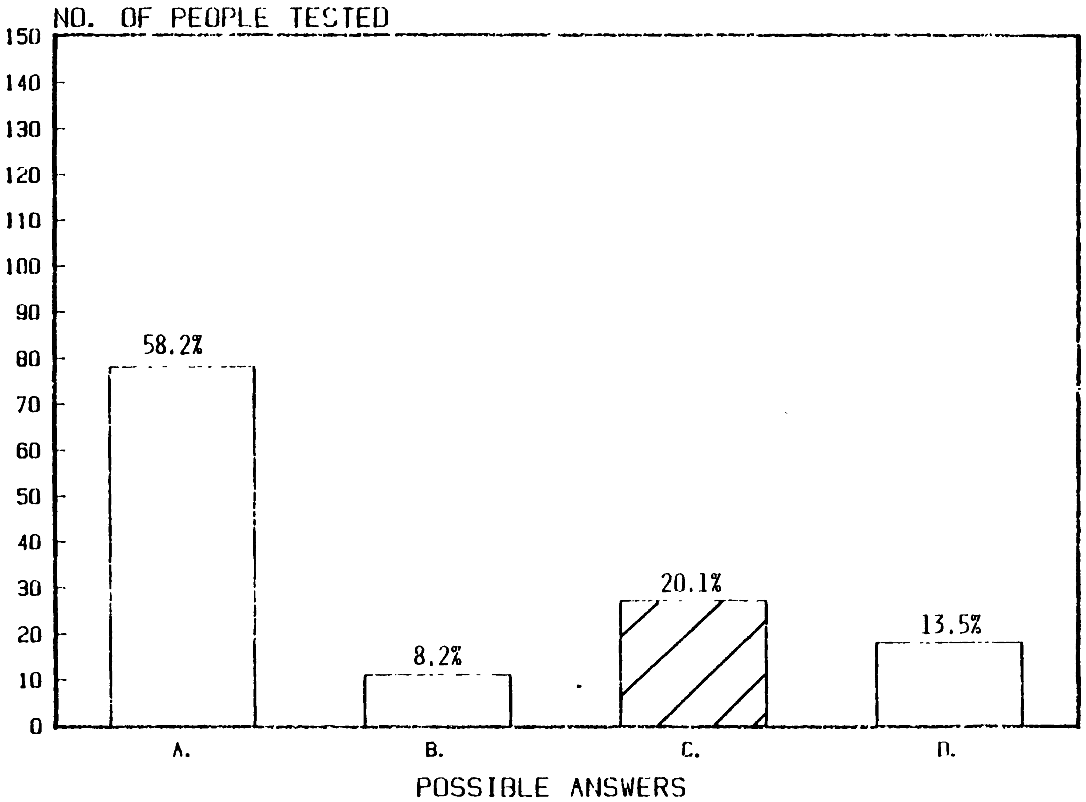
(A) softness

(B) salinity

(C) hardness

(D) pH

QUESTION FORTY-SEVEN



No. 47. A permeable area where water can seep rapidly into the aquifer is called a ______.

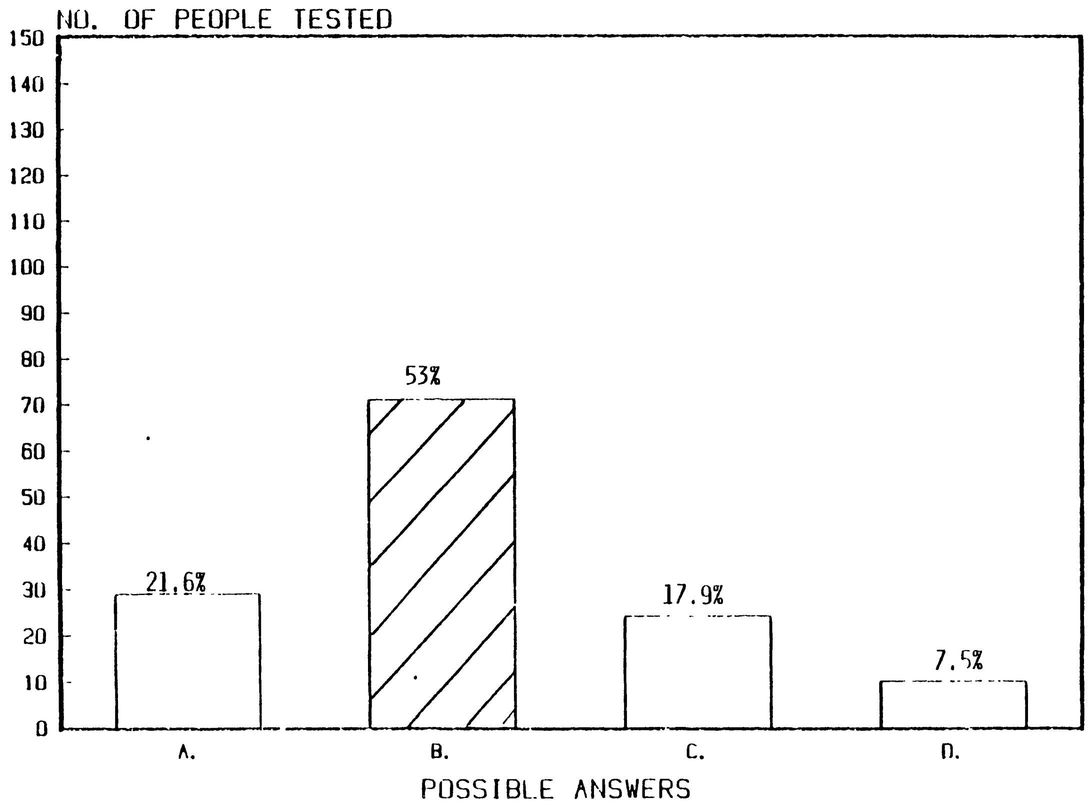
(A) seepage area

(B) roundup area

(C) recharge area

(D) water area

QUESTION FORTY-EIGHT



No. 48. Building more reservoirs is not the solution to the problem of municipal water shortage in our region because ____________.

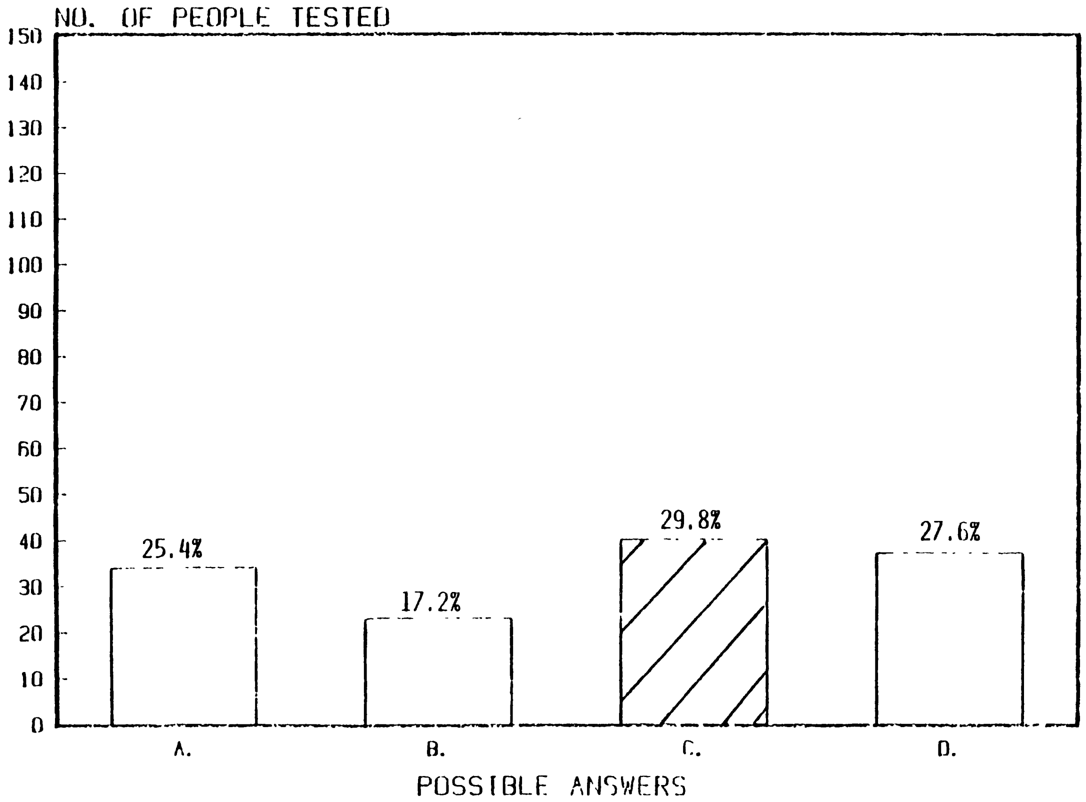
(A) we need our ground water for industry and irrigation

(B) the quantity of surface water available to fill reservoirs is limited

(C) it is too costly to purify the water pumped from reservoirs

(D) we don't need the noise and water pollution caused by more power boats

QUESTION FORTY-NINE



No. 49. Prohibiting yard watering could reduce municipal water consumption by about _________.

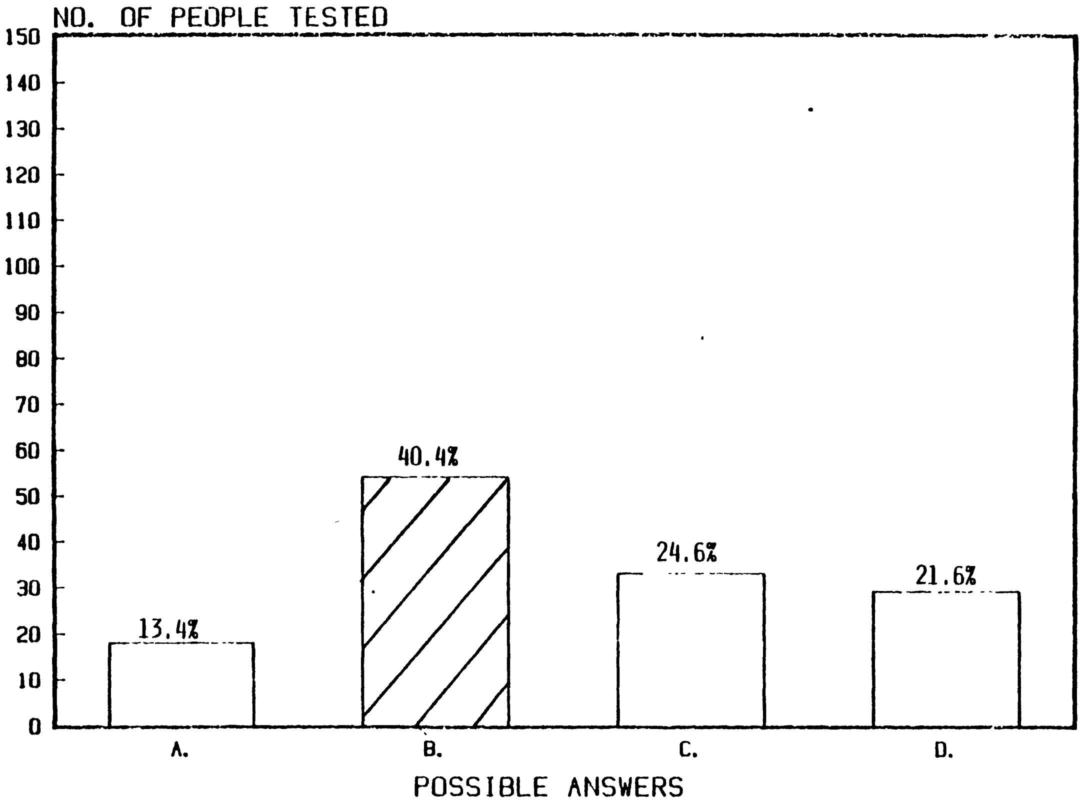
(A) 10 percent

(B) 25 percent

(C) 35 percent

(D) 50 percent

QUESTION FIFTY



No. 50. Recycling treated waste water could reduce supply requirements in our larger cities by an additional __________.

(A) 10-20 percent

(B) 25-30 percent

(C) 30-35 percent

(D) 45-50 percent

VITA 2

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Doctor of Philosophy

Thesis: AN ASSESSMENT OF THE PUBLICS' WATER RESOURCE KNOWLEDGE AND IMPLICATIONS FOR WATER EDUCATION

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Professional Experience: High school science teacher for Harrah Public School, Harrah, Oklahoma, 1979-1981; Graduate Assistant with Natural Resources and Environmental Education Center 1981-82; Graduate Assistant with National Aeronautics and Space Administration 1982-85.

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